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The Effects of Virtual Rehabilitation Following Acquired Brain Injury: A Feasibility Study

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A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

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(Thesis format: Monograph)

by

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Abstract

Increasingly the Nintendo Wii has been cited as an adjunctive tool for physical rehabilitation among healthy young and older adults, and among a diverse range of patient populations (e.g., Parkinson's disease, Cerebral Palsy, and Down syndrome) in clinical settings. However, evidence supporting the implementation of Wii-habilitation in community settings remains limited. The present study evaluates the feasibility of a 4-week community based exercise program using the Nintendo Wii™; as a tool for improving balance in individuals with Acquired Brain Injury (ABI) several years post injury. This study also evaluates whether use of the Wii™ in this context may lead to clinically significant changes in occupational performance and/or community integration.

Seven individuals with ABI engaged in two 30-minute Wii™ balance training sessions per week, for 4 weeks. Results extend previous findings to suggest that the Wii™ is a feasible tool that can be used to foster positive effects on balance, occupational performance, and community integration among individuals with ABI in a community setting. Future research is warranted to extend this line of inquiry with both a more potent intervention and larger sample.

Key Words: Acquired Brain Injury, Nintendo Wii™, Balance, Occupational Performance, Community Integration

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List of Abbreviations

ABC: Activities-specific Balance Confidence scale

ABI: Acquired Brain Injury

BADLs: Basic Activity(ies) of Daily Living

BBS: Berg Balance Scale

BWSTT: Body Weight-Support Treadmill Training

CB&M: Community Balance and Mobility scale

CIQ: Community Integration Questionnaire

COPM: Canadian Occupational Performance Measure

FRT: Functional Reach Test

IADLs: Instrumental Activity(ies) of Daily Living

IBICA: International Brain Injury Clubhouse Alliance

mCB&M: modified Community Balance and Mobility scale

PT: Physical Therapy

SPSS: Statistical Package for the Social Sciences

TBI: Traumatic Brain Injury

VR: Virtual Reality

VRehab: Vestibular Rehabilitation

Chapter 1: Introduction and Literature Review

Acquired Brain Injury (ABI) is an all-inclusive term including all types of brain injuries: both traumatic brain injury (TBI) (e.g., as a result of falls, motor vehicle collisions, sports related incidences) and non-TBI other injuries to the brain after birth that are not related to a congenital or degenerative disease (e.g., cerebral vascular accidents, lack of oxygen to the brain, tumors, aneurysms, and infections of the brain; Greenwald, Burnett, & Miller, 2003; Teasell et al., 2007). ABIs can result in behavioural/ emotional, cognitive, and physical impairments that in turn affect an individual's everyday life (National Institutes of Health [NIH], 1999). For example, impairments to behavior and emotions may negatively impact mood and self-esteem that could result in difficulties with engagement and participation in social settings (Durstine et al., 2000). Similarly, physical impairments such as balance and motor coordination deficits may negatively impact functional activities such as dressing or climbing stairs (Basford et al., 2003; Wade, Canning, Fowler, Felmingham, & Baguley, 1997). Although for many years a wide held belief was that whatever recovery was going to occur would likely take place within the first twelve months, this is no longer believed to be true. Specifically, recent research suggests that functional gains may continue to be realized several years post injury (Svendsen & Teasdale, 2006). To this regard, the present study examines the feasibility and utility of implementing a rehabilitation program designed around the commercially available virtual reality gaming system, the Nintendo Wii™ aimed at improving balance among individuals living with an ABI well after the initial time of injury. Provided that it is possible for improvements in balance to translate into improved occupational performance and community integration, the utility of the Wii™ intervention to improve these latter two domains (via improvements in balance) was also examined.

Epidemiology of ABI

ABI is the leading cause of death and disability in Canada, affecting over half a million Ontarians (Colantonio, 2011). It has been estimated that the annual incidence rate for severe traumatic brain injuries (TBI) is 11.4 per every 100,000 (Zygun et al., 2005), and 600 per every 100,000 for mild TBIs (Cassidy et al., 2004). The recently published *Ontario Acquired Brain Injury (ABI) Dataset Project* found that the rate of TBI in emergency departments and acute care increased from 17,019 in 2003/2004 to 25,760 in 2009/2010, and that the rate of non-TBI increased from 24,353 in 2003/2004 to 27,525 in 2009/2010 (Colantonio, 2011).

Gender related differences.

Most studies indicate that, irrespective of age, males are at an increased risk of acquiring a brain injury than are females (e.g., Pickett, Ardern, & Brison, 2001). Specifically, it has been reported that males are three times more likely to acquire this type of injury (Greenwald et al., 2003), with those at greatest risk being between 15-24 years of age (Murdoch & Thoeodoros, 2001). Most of the injuries sustained among this age group have been identified as being related to motor vehicle accidents (Pickett et al., 2001). Much of the differences found between rate of injuries between males and females can be attributed to the fact that males tend to engage in a greater degree of high-risk activities, are exposed to more severe vocational hazards, and often participate in activities prone to involve violence (Cassidy et al., 2004). Males are also more at risk to sustain a mild TBI if they experience low cognitive function, are frequently intoxicated, or are of low-socioeconomic status (Nordstrom, Edin, Lindstrom, & Nordstrom, 2013)

Age related differences.

Although transportation accidents and falls account for the most common cause of ABIs across the lifespan (Andelic, 2013; Falk, 2010; Langlois, Rutland-Brown, & Wald, 2006; Thompson, McCormick, & Kagan, 2006), some differences in etiology exist across age groups. For example, child abuse, and sporting accidents are common causes of ABIs for children (Falk, 2010), for adolescents transportation accidents remain the primary mechanism of injury accounting for over half of all ABIs (Murdoch & Thoeodoros, 2001). In contrast, individuals over the age of 40 are more likely to incur non-traumatic injuries such as: vascular insults, brain tumors, meningitis, encephalitis and anoxia (Thompson et al., 2006), while individuals over the age of 60 are most likely to sustain injury due to an unexpected fall (Rapoport & Feinstein, 2000; Thompson et al., 2006; Wilson, Pentland, Currie, & Miller, 1987).

In addition to the variability in etiology reported across the lifespan, individuals of various ages are likely to be differentially impacted by the injury. For example, research has identified that advanced age is a risk factor for higher rates of mortality and morbidity (Mosenthal et al., 2002). Specifically, the number of hospital deaths related to ABI has been reported in seniors aged 60 years and over as being close to seven times higher than in comparison to those who were injured under the age of 19 years (Ratcliff, Colantonio, Escobar, Chase, & Vernich, 2005). It has also been reported that following a brain injury, individuals over the age of 65 perform more poorly in comparison to a younger cohort on cognitive tests such as those that involve word fluency, visual and verbal memory, abstract reasoning and processing speed (Ashman et al., 2008; Senathi-Raja, Ponsford, & Schonberger, 2010).

Research has also identified that individuals over the age of 60 require additional resources to recover in comparison to younger patients who have sustained a similar injury (Pennings, Bachulis, Simons, & Slazinski, 1993). For example, Roy, Pentland, and Miller (1986) reported an increased length of hospitalization among older patients recovering from a brain injury. Similarly, older patients have been identified as requiring significantly longer lengths of stays in rehabilitation compared to patients younger than 55 years of age (Cifu et al., 1996). Moreover, it has also been reported that elderly patients are more likely to require increased family involvement and community support services, or require a change of residence (LeBlanc, de Guise, Gosselin, & Feyz, 2006). One explanation that has been proposed to account for the slower rates of functional gain is that older adults may have less neuronal plasticity thereby negatively affecting the brain’s ability to compensate in the same way a younger brain does post injury (Senathi-Raja et al., 2010). Furthermore, the aging process is often accompanied by numerous developing conditions, such as diabetes, arthritis, cardiovascular and cerebrovascular disease that may serve to complicate and delay the recovery process (Dijkers, Gordon, Abreu, Graham, & Charness, 2008; Mosenthal et al., 2002).

Common Symptoms of ABI

Depending on the nature and location of injury, individuals living with an ABI can experience a large range of adverse physical, behavioural/emotional, and cognitive impairments detectable through a vast amount of residual symptoms (Turner-Stokes, Disler, Nair, & Wade, 2005). For example, common symptoms may include: headaches, blurry and/or double vision, sensitivity to light, fatigue, communication deficits, poor short and long term memory, and problems with balance and dizziness, to mention just a few (Faux & Sheedy, 2008; Fowler, Wade, Richardson, & Stein, 1996; Jackowski, Sturr, Taub, & Turk, 1996; MacDonald & Wiseman-Hakes, 2010; Norrie et al., 2010; Ownsworth & McFarland, 1999). Moreover, individuals may also develop a spectrum of disorders including mood and personality disorders (resulting in aggressive behaviours,) eating disorders (resulting in appetite and weight changes), sleep disorders, (resulting in social withdrawal, feelings of being worthless, or suicidal thoughts) and post-traumatic stress (Castano & Capdevila, 2010; Kolakowsky-Hayner et al., 2002; Kreutzer, Seel, & Gourley, 2001; McMillan, Williams, & Bryant, 2003; Rao & Lyketsos, 2000). Individuals who have sustained a brain injury also frequently turn to substance abuse (drugs and/or alcohol) to help them cope with the adverse symptoms and disorders they experience (Kolakowsky-Hayner et al., 2002).

While individuals living with acquired brain injury experience functional limitations due to impairments across all of the aforementioned domains (i.e., physical, behavioural, emotional, and cognitive), impairments within the physical domain, specifically impairment to balance, have been reported to be particularly troublesome (Gurr & Moffat, 2001; Mrazik et al., 2000). Given that the ability to balance is essential to complete activities of daily living safely and independently (Feld, Rabadi, Blau, & Jordan, 2001), and that estimates suggest that 33% of individuals who sustain a brain injury experience post traumatic postural control and coordination deficits (Wober et al., 1993), this thesis will primarily focus on impairments to balance.

Balance Impairments in ABI

In general, balance can be defined as the "even distribution of weight, enabling someone or something to remain upright and steady" (Oxford Dictionary, 2013). Biomechanically, balance can be defined as the ability to maintain the body's centre of gravity within the limits of stability as determined by the base of support (Alexander, 1994; Horak, 1987). The human balance system consists of three sensory systems: somatosensory (sight and touch), vestibular (motion, equilibrium, and spatial orientation), and cerebellar (coordinating motor activities and learning new motor skills) each system has specific functions that work in alliance to maintain normal posture (Lundy-Ekman, 1998). A brain injury can and often does affect one or all these systems (e.g., Franke, Walker, Cifu, Ochs, & Lew, 2012; Guzzetta et al., 2007). Richter (2005) describes some of the deficits that individuals living with a brain injury may experience that may result in impairments to balance. These include: motor deficits that affect bodily position: lack of coordination in the limbs (also known as ataxia): vestibular deficits causing functional impairments: and unstable gait that can lead to falls.

Balance impairment and occupational performance.

Balance is a heavily relied upon ability that is the foundation for mobility and overall functional independence across the lifespan (e.g., allows for the completion of day-to-day actions, motions, and routines; Yim-Chiplis & Talbot, 2000). When a disruption occurs to one or all systems (vestibular, somatosensory or cerebellar) that results in balance becoming impaired, a barrier is created that limits an individual's occupational performance. Occupational performance is described as the capacity to reasonably act out occupations that are "meaningful and culturally relevant in taking care of one's self (self-care), being a contributory member of society" (productivity), and participating in recreational activities (leisure) (Devitt et al., 2006, p.1). Specifically, impairments to balance can limit an individual's occupational performance in self-care by hindering both basic activities of daily living (BADLs) (e.g., washing, grooming, dressing and undressing), and instrumental activities of daily living (IADLs) (e.g., shopping, cooking, laundry, cleaning, and finances). Secondly, impairments to balance can negatively impact one's productivity by making it challenging and/or potentially unsafe to engage in child care, complete housekeeping, homemaking, or paid work tasks (McNamee, Walker, Cifu, & Wehman, 2009; Powell, Temkin, Machamer, & Dikmen, 2007; Wise et al., 2010). Lastly, impaired balance can affect leisure activities by limiting one's ability to travel, participate in outdoor activities (e.g., camping, fishing, hiking), compete in individual and group sports, and engage in social gatherings with family and friends, among others (Bier et al., 2009; Eriksson, Tham, & Borg, 2006; Wise et al., 2010).

Impaired balance can also lead to a fear of falling that further limits occupational performance. Collicutt McGrath (2008) established a direct connection between impaired balance, fear of falling, and avoidance of daily activities that have motor and balance components, all crucial for occupational performance. Moreover, Collicutt McGrath (2008) notes that falls are common amongst individuals with neurological impairments due to problems associated with gait and balance, especially when tasks require static or active balance such as, shifting of weight like transferring in and out of a chair, walking on uneven surfaces such as rocky pathways, standing during the performance of activities, and access to car travel.

Balance Impairment and Community Integration

Impairment in balance can also have a negative effect on community reintegration. Although a clear definition of community integration remains to be established, McColl et al. (1998) characterized this concept using a client-centered approach among individuals with brain injuries. Specifically, when participants were asked to describe community integration, the following nine themes emerged: conformity, acceptance, orientation, close relationships, diffuse relationships, productivity, leisure, independence exercising self-determination in terms of one's own abilities, and living situations. Of particular interest to this thesis are the dimensions, productivity, leisure, and living situations, as it is likely that impairments in balance (as discussed above) would impact upon their attainment.

In general, the aforementioned emergent themes suggest that community integration is reliant on individuals having workable and flexible relationships with others, choice about one's degree of independence in living situations, and control over engagement in meaningful and satisfying activities to fill one's time. For example, community reintegration requires the ability to adhere to community standards of conduct, including knowing how to and being able to conduct oneself in such a way that one "blends in", and being able to participate in paid work as well as unpaid productive activities. Most importantly, community integration is about being independent for example, not solely about being able to live alone, but also about being able to have a say in one's own life. Much of the literature indications that, when balance is impaired, individuals also experience a deleterious impact on BADLs, IADLs and productive and leisure activities (e.g., Hillier, Sharpe, & Metzer, 1997; Hyndman & Ashburn, 2003) thus an individual may have greater difficulty fully connecting with their community. Similarly important, is to note that community reintegration following a brain injury is not simply about getting back to life the way it was; but rather it is about being accepted for who someone has become after the brain injury, re-kindling close relationships with family, as well as making new friendships (McColl et al., 1998)

Current Approaches to ABI Balance Rehabilitation

Several types of therapy have been used to address balance impairments amongst individuals with ABI. Traditional forms of balance rehabilitation have been based on methods from physical therapy, such as body weight-support treadmill training (BWSTT) (e.g., Scherer, 2007; Wilson & Swaboda, 2002), vestibular rehabilitation (VRehab) (e.g., Gurr & Moffat, 2001; Thornton et al., 2005), and conventional physical therapy (PT). A recent systematic review of the literature identified that certain physical therapy methods can lead to overall improvements in gait and balance for individuals with TBI (Bland, Zampieri, & Damiano, 2011). Of the studies that Bland et al., 2011 identified as specifically administering balance training, those by Gurr and Moffat (2001), Herdman (1990), and Yan (2008) revealed significant improvements in balance.

Gurr and Moffatt (2001) administered a VRehab program to a sample of 18 outpatients with TBI, all of which experienced symptoms of dizziness and balance impairment. VRehab lasted for six weekly one-hour sessions and involved participation in a standardized set of vertigo exercises, graduated exposure to movement, and involvement in psychoeducation and psychotherapy. Balance and vertigo were assessed at baseline, pre-test, and post-test using a series of self-report questionnaires and a physical sway-monitor assessment. This study revealed that, following therapy, participants' balance had improved, vertigo problems had decreased, degree of disability had lessened, level of emotional distress had reduced, and quality of life had improved (Gurr & Moffat, 2001).

The study by Herdman (1990) also reported the results of VRehab-based interventions for individuals with TBI. In this study, three single case studies of individuals experiencing vertigo, postural instability, and balance impairments were presented. The specific participant described in the first case experienced unilateral vestibular loss, and thus engaged in a series of exercises designed to enhance vestibular function and improve postural stability. These exercises targeted gaze and postural stability, and required the participant to focus on a string of words and, subsequently, move the head so as to facilitate the dynamic vestibule-ocular response and visuo-vestibular interactions. The study reported that, after six months, the participant's overall functional activity and postural stability improved to the point that he/she no longer needed a cane to walk (Herdman, 1990b).

The participant in the second case experienced benign paroxysmal positional vertigo (Herdman, 1990). For this treatment, the participant was required to move into positions that evoked vertigo several times each day. The exercises for this treatment were repeated every three hours until the patient successfully experienced two consecutive days without vertigo. It was reported that treatment was successful in improving the participant's level of postural stability (Herdman, 1990).

The participant in the third case experienced bilateral vestibular loss (Herdman, 1990). Treatment in this case was based on developing alternative strategies to replace lost vestibular function, particularly targeting gaze and postural stability. Treatment exercises were specifically aimed at facilitating compensatory mechanisms and voluntary control, and potentiating the cervico-ocular reflex. These exercises all involved looking at a target and manipulating the head and eye movements. This case also reported to be successful in treating the patient's balance impairments and level of vertigo (S. J. Herdman, 1990).

The final study by Yan et al. (2011) demonstrated significant improvements in balance investigated the efficacy of combining conventional PT with principles of cognitive rehabilitation. Conducted by Yan (2008) this study presented the results of a single case study of an individual with TBI. The participant in this particular case report experienced postural instability and attention control, which was specifically manifested by difficulty in standing up, difficulty maintaining postural stability in a standing position, and inability to ambulate. After four weeks of inpatient treatment, it was reported that postural stability during standing was significantly improved, and that overall levels of independence and safety had increased (Yan, 2008).

Bland et al., (2011) also reported results from treatment programs that incorporated both gait and balance techniques. In the studies by Scherer (2007) and Wilson and Swaboda (2002), BWSTT was used in conjunction with conventional PT to improve gait and balance in participants with TBI. BWSTT is a method of restoring gait and postural abnormalities for individuals who are incapable of fully supporting their own body weight. Treatment progression throughout the course of BWSTT training can exist either by progressively increasing the amount of body weight the individual is expected to bear (termed as graduated "unweighting"), or, by gradually increasing the speed of locomotion (Scherer, 2007; Wilson & Swaboda, 2002).

Scherer (2007) reported a single case of an inpatient at a rehabilitation hospital undergoing daily BWSTT and PT interventions to improve postural stability and mobility. For this particular participant, the progression of BWSTT was characterized by increasing treadmill speeds with the goal of maintaining gait quality and postural stability. The study found that BWSTT and PT led to improvements in gait and balance, with increases found on all outcome measures assessing gait, walking distance, and balance (Scherer, 2007).

Wilson and Swaboda (2002) reported the results of two individual case studies, both of which were inpatients undergoing extensive PT for their difficulties with gait and balance. The BWSTT addition to their PT treatment utilized a partial body support system in which unweighting was accomplished through use of a modified Lat Pulldown machine with 10-pound increments. Both participants completed 2-hourly sessions of BWSTT as a part of their PT program for an 8-week period. Both patients showed modest improvement in balance, walking ability, level of functional ambulation, spasticity level, and muscle strength. By the end of the treatment period, one participant was capable of ambulating independently with the assistance of a walker, while the other participant developed most component abilities of ambulation, and only lacked muscular strength needed to ambulate independently (Wilson & Swaboda, 2002).

In more recent research, Fritz and Basso (2013) documented the feasibility of dual-task training in addition to standard PT incorporating stair climbing, gait training, balance training, and orientation exercises. This particular PT protocol was administered to an individual with TBI within an inpatient rehabilitation setting and incorporated two distinct phases: a baseline period, lasting for 7 days (Phase A), and the dual-task intervention period, also lasting for 7 days (Phase

B). In Phase A, PT interventions targeting body stability and transportation were administered, with each intervention beginning in a closed environment and gradually progressing to open environments. Specific balance interventions in this phase included practicing static standing with a narrow base of support, and quick turning progressing to obstacle courses challenging dynamic balance. Dual-task training in Phase B occurred for an average of 15 minutes per each daily 30-minute PT session, and included motor-motor and cognitive-motor dual tasks. Specific intervention strategies included static standing, narrow base support, and quick turning which progressed to included distracting activities such as balancing on a foam block while folding laundry or putting a puzzle together while walking and talking. The participant revealed modest improvement in performance on divided attention tests, clear improvements in functional tasks (i.e., walking speed and time to descend stairs), and improvements in balance and postural stability. The study concluded that the addition of dual-task interventions might be effective in improving function in TBI (Fritz & Basso, 2013).

While traditional balance programs such as those outlined above have generally been proven to be helpful in improving balance, they often require participants to engage in tasks that are repetitive and not very stimulating. As a result, participants may lose interest, become less engaged with the rehabilitation process, and demonstrate decreased levels of programmatic adherence. Moreover, Berger, Jones, Pyle, and Patrikeeva (2012) discussed the current feasibility of traditional PT techniques in treating balance impairments, stating that such techniques are expensive, time-consuming, and ineffective in adequately engaging patients. Furthermore, PT interventions can only be conducted with a clinician, and usually feedback is only provided to the clinician. Therefore, the patient often does not receive feedback during the course of the intervention, which makes PT highly impractical as a practice tool for patients. Berger et al. (2012) argue that, if patients did receive feedback, and were able to practice the interventions outside of a clinical setting, then more benefit from the interventions would likely develop.

One adjunctive strategy that may serve to create and sustain user interest in the rehabilitation process is the use of virtual reality (VR) training. For many patient populations virtual reality training has been embraced within rehabilitation settings, and is showing very promising results in creating lasting motor changes. For example, the effects of virtual reality rehabilitation has been investigated among individuals recovering from stroke, as well as individuals with spinal cord injury and cerebral palsy, and all of these populations have demonstrated positive outcomes when compared with standard rehabilitation approaches (Kiznoy, Katz, & Weingarden, 2002). Particularly relevant to this thesis are studies by Thornton et al. (2005) and Yip and Man (2009) that examined VR among individuals living with a brain injury. Thornton et al. (2005) examined outcomes of therapy among individuals with moderate to severe TBI who participated in either an activity-based or VR-based exercise training program designed to improve balance. Results indicated that participants from the VR group had better outcomes on quantitative measures of balance and that participants and their significant others were more enthusiastic, motivated, and expressed greater interest and excitement about using a VR simulation compared to traditional therapy methods. Along similar lines of inquiry, Yip and Man (2009) demonstrated the usability and effectiveness of a VR program designed to provide community living skill training to individuals with acquired brain injury. As was identified by Thornton et al. (2005) a positive training effect was identified and participants reported that they were interested in and motivated by their involvement in the VR training program.

Although as a whole the research suggests that groups participating in virtual reality rehabilitation tend to have more favorable outcomes than groups that are not exposed to this adjunctive therapeutic approach (Holden, 2005), most studies have focused on high-end, custom hardware and software, that is neither readily available nor affordable, thus making it unsuitable for clinical or community implementation. In response to these limitations, researchers have recently focused their attention on consumer grade technology as it addresses both of these concerns. Specifically, the Nintendo Wii™ gaming console has drawn considerable attention from both the research and clinical community.

The Nintendo Wii™

Secondary to its low cost, ease of use, and portability, the Nintendo Wii™ gaming system is quickly becoming one of the most utilized ways of delivering VR based exercise as therapy within a variety of populations (Bainbridge, Bevans, Keeley, & Oriel, 2011). First released in 2006, the Nintendo Wii™ is an interactive gaming system based on the use of motion-control.

The system is comprised of a console that attaches to a standard television, a wireless handheld controller, and several additional peripherals. Body movements are enhanced through the Wii™ controller which "is the heart of the motion gaming experience… it responds to motion and rotation for enhanced control as you swing, swipe, thrust, or turn the controller" (Nintendo®, 2013, para.2). The Wii™ console tracks the motions of the Wii™ remote, duplicating the motions on a television screen. Unique accessories are often paired with the Nintendo Wii™, such as a second controller called the "Nunchuck" (Nintendo®, 2013, para.4) to enhance game play or the very popular "Wii Fit Plus™" package (Nintendo, "Wii Accessories, 2013, para. 6) that comes with the "Wii Balance Board™". Similar to that of a bathroom scale, the board contains four force transducers that measure body weight, respond to shifts in body position (Meldrum, Glennon, Herdman, Murray, & McConn-Walsh, 2012), and provides "real-time visual and auditory feedback of a person's center of pressure" (Meldrum et al., p. 2). Provided these unique characteristics it is believed that the Wii Balance Board™ may prove to be a valuable rehabilitation tool, particularly beneficial in therapy with clients experiencing balance issues.

The Nintendo Wii™ as a rehabilitation tool.

From the time of its release in 2006, the Nintendo Wii™ has been cited as a potential adjunctive tool for physical rehabilitation, specifically balance training. The use of the Wii™ system as a tool to train balance has many potential benefits over that of traditional therapy. In general, traditional therapy is relatively expensive, and can result in diminished levels of adherence as individuals are required to practice repetitive and uninteresting tasks. Alternatively, the Wii™ system is a low cost commercially available option. With several interactive game options available to select from, the literature suggests that the Wii™ is fun and enjoyable, and may help to foster increased levels of adherence (Williams, Doherty, Bender, Mattox, & Tibbs, 2011).

Since the Wii™ emerged as a promising new delivery method of rehabilitation, evidence supporting the utility of the Wii™ in a rehabilitation context continues to expand. For example, research has examined the utility of the Wii™ within samples of healthy young and older adults, and among several patient populations including individuals living with a brain injury as discussed below.

Wii-habilitation with young adults.

Although reported to a lesser extent then with other populations (i.e., older adults, individuals with neurologic impairment), a handful of studies have examined the utility of the Wii™ in a rehabilitation context among healthy young adults. For example, Graves, Ridgers, and Stratton (2008) examined the utility of the Nintendo Wii™ as a means to increase physical activity levels among adolescents between 11-17 years of age. Participants were provided with a Nintendo Wii™ console and asked to engage in three Wii™ games (tennis, bowling, and boxing) while physiological measures of heart rate and energy expenditure were recorded. Results demonstrated that actively playing the Wii™ significantly increased both outcome measures, thus suggesting that engaging in Wii™ activities has the potential to lead to positive health benefits. Clark et al. (2010) also examined the utility of implementing the Wii™ in a rehabilitation context among a sample of healthy young adults. In their study, they compared balance data that were collected on both a Wii Balance Board™ and a gold standard biomechanical forceplate during the performance of four standing tasks. Compared to the gold standard, the Wii Balance Board™ proved to have excellent test-retest reliability and validity thus indicating that the Wii Balance Board™ has potential in becoming an innovative tool that affords clinicians the ability to objectively assess balance. Most recently, Vernadakis, Gioftsidou, Antoniou, Ioannidis, and Giannousi (2012) examined the utility of using the Nintendo Wii Balance Board™ and associated Wii Fit Plus™ games to improve the balance of a sample of undergraduate physical education students. Following an 8-week training program, statistically significant improvements on the pre-post balance scores were demonstrated.

Wii-habilitation with older adults.

Several studies have also examined the Nintendo Wii™ as a tool to improve balance among older adults. Bainbridge et al. (2011) delivered a 6-week intervention focused on the Wii Fit™ system to improve balance amongst a sample of community dwelling older adults. Results identified significant improvements from pre-test to post-test scores on several measures of balance. Similarly Young, Ferguson, Brault, and Craig (2011) utilized the Nintendo Wii Balance Board™ to train standing balance in older adults using specially designed games. Six healthy older adults participated in 4-weeks of game play consisting of 10, 20-minute sessions. Medial-lateral and anterior-posterior sway variability was noted to decrease in both eyes open and closed conditions; however, statistically significant improvements were found only in the eyes closed anterior-posterior sway condition. Pigford and Andrews (2010) conducted a 6-week Wii™ intervention study with community-dwelling older adults and, although there were no statistically significant differences in the outcome measures assessed, clinically significant improvements in the Berg Balance Scale (BBS) were noted in four of the six participants. Bomberger (2010) used the Wii FIT with eight older adults between 79 to 93 with no balance concerns and six adults between 80 to 91with mild to moderate balance concerns and found significant improvements in balance in both groups. Finally, Bateni (2012) conducted a preliminary study which compared changes in balance experienced by healthy older adults following a 4-week exercise program that used the Wii Fit™ gaming system and/or traditional physical therapy. Participants' were placed in one of the following three groups: 1) combination physical therapy and Wii™ training, 2) only physical therapy, and 3) only Wii™ training. Although results indicated all groups showed improvements in balance, the group that received a combination of both PT and Wii™ training demonstrated the greatest overall improvements. Given these positive findings it is not surprising that research in this area continues to move forward at an increasingly rapid pace.

Wii-habilition with patient populations.

Using the Nintendo Wii™ as an adjunctive therapy, researchers have also demonstrated its efficacy among individuals with diverse rehabilitation needs, who are often less physically active, thus limiting their ability to have a healthy lifestyle. For example, Deutsch, Borbely, Filler, Huhn,and Guarrera-Bowlby (2008) examined the efficacy of the Wii™ to augment the rehabilitation of an adolescent with cerebral palsy. Significant improvements were noted in postural control, functional mobility, and visual perceptual processing. Alvarez and Rodriguez (2009) employed a case study design to examine the effectiveness of a 6-week Wii™ exercise program designed to improve the balance of a 68 year old male with an 8 year history of Parkinson's disease. Results illustrated a decrease in disease severity and suggested that the

Wii™ program could provide a safe, effective and enjoyable method to reduce physical inactivity. Wuang, Chiang, Su, and Wang (2011) examined the sensorimotor changes in children with Down Syndrome using the Nintendo Wii™ compared to standard occupational therapy. Results indicated that participants in the Wii™ group had greater pre-post changes in motor proficiency, visual-integrative abilities, and sensory integrative functioning. As compared to those receiving standard occupational therapy treatment, thus demonstrating that the Wii™ could be used as a successful adjunctive form of treatment. Shih, HShih, and Chu (2010) examined the effectiveness of using the Wii Balance board™ to improve standing posture among two individuals with cerebral palsy. In their study, Shih et al. (2010) interfaced the Wii Balance Board™ with a microcomputer such that visual stimulation (i.e., cartoons) would be presented when participants entered into and maintained a correct standing posture. Following several home based training sessions, both participants were noted to have substantially increased the length of time they were able to enter into a correct standing posture. Miller, Hayes, Dye, Johnson, and Meyers (2012) investigated the use of the Wii Fit™ balance games and body weight support to improve balance among two individuals with a lower limb amputation. Following a 6-week intervention both participants demonstrated improvement in dynamic balance and balance confidence with one participant reducing the need for an assistive device in community ambulation and the other participant improving his aerobic capacity. Most recently, Holmes, Gu, Jenkins, and Johnson (2013) examined the effects of a 12-week home based rehabilitation program based on the Wii Balance Board™ that was designed to improve balance among 11 individuals with Parkinson's disease. Although results failed to reach statistical significance, a general trend for balance to improve emerged. Consistent with previous results, Holmes et al. (2013) concluded that implementing an exercise regime that uses the Wii™ system is a viable option for improving balance among individuals with neurologic impairment.

Wii-habilitation with individuals with ABI.

While the Wii™ has been examined for its efficacy among several diverse medical conditions, including ABI, a majority of the initial research in this area has focused on its utility as a post stroke rehabilitation tool. Specifically, within this population the Wii™ has been examined for its utility in fostering improvement in upper and lower extremity motor function, as well as balance.

In one example, Saposnik, Levin, and Outcome Research Canada Working (2011) demonstrated with a pilot clinical trial that the Nintendo Wii™ is a feasible, safe and effective rehabilitation tool for use with stroke patients. In this particular intervention, nine individuals undergoing standard rehabilitation for stroke (i.e., physiotherapy and occupational therapy) participated in a Nintendo Wii™ intervention with a focus on upper extremity motor function. This group was compared to a random control group receiving recreational therapy that incorporated various leisure activities. Each group received their corresponding interventions for a total of eight hourly sessions over the span of 14 days. Following the intervention, the experimental group exhibited significant gains in mean motor function, as well as a high tolerance to time commitment thus indicating the interventions feasibility.

In an examination of lower limb motor function after stroke, Ding et al. (2013) demonstrated that the Nintendo Wii Fit™ gaming system could be an effective tool for encouraging stroke patients with hemiparesis to increase the use of their paretic leg. In this study, two individuals with chronic stroke participated in one week of a Nintendo Wii™ intervention using balance training and manipulated control gains. This Wii™ intervention was administered in conjunction to a 3-week conventional rehabilitation program. Results were compared to a similar control group, which consisted of one individual with chronic stroke who received three weeks of conventional rehabilitation alone. This study revealed that, by using the Wii™ to independently manipulate the influence of each leg, participants in the experimental condition showed improvement in weight symmetry, dynamic stability, and the ability to maneuver their center of pressure.

The Nintendo Wii™ has also been identified as a feasible and effective rehabilitation technique with interventions targeting balance and postural stability alone in stroke patients. For example, Brown, Surgarman, and Burstin (2009) reported the results of an elderly individual that incorporated the Wii™ as part of her recovery following stroke. Treatment involved standard PT with four training sessions in the Wii Fit™ gaming system. Prior to treatment, this particular individual was unable to walk without close supervision and, following treatment, was reported as being capable of walking with a walker and minimal supervision. Pre- and post-test measures revealed a 10-second improvement in the Timed Up and Go test, a 3-point increase in Berg Balance Scale, and improved anterior-posterior stance symmetry following the Wii™ intervention. Patient feedback indicated that the Wii™ was a highly enjoyable addition to treatment, and did not cause any discomforting symptoms or adverse events during game play.

Similar results have also been produced by slightly larger studies, such as that by Celinder and Peoples (2012). In this study, a diverse sample of nine individuals recovering from stroke engaged in a non-specific Wii Sports™ intervention for a span of three weeks during hospital rehabilitation. Semi-structured qualitative interviews revealed that the participants found the intervention to be beneficial in providing variety, generating a desire for more meaningful occupations, and stimulating motivation and positive engagement in therapy. This study thus concluded that the Wii™ is a suitable replacement for conventional occupational therapy programs.

In a similar study, Lange, Flynn, Proffitt, Chang, and Rizzo (2010) interviewed eight individuals with various neurological conditions (including stroke) concerning their experience using the Wii™ program as part of their rehabilitation. It was reported by all participants that Wii™ activities were more enjoyable and engaging than conventional physical and occupational therapy, yet, equally strenuous. Specifically, participants described enjoying the hard work when involved with the Wii™, which subsequently led them to want to work harder. This study concluded that the Wii™ is a clinically useful and enjoyable rehabilitation tool.

In further support of the discussed findings, the study by Gil-Gomez, Llorens, Alcaniz, and Colomer (2011) also found results to suggest that, instead of utilizing traditional rehabilitation processes that are based on repetition of movement, innovative technology such as virtual reality can be utilized to maximize recovery in ABI.

Harvey and Ada (2012) investigated the suitability of specific Nintendo Wii Fit Plus™ games to determine which were the most appropriate and effective in targeting standing impairments in stroke rehabilitation. Two independent reviewers rated a total of 75 games to determine each game’s level of difficulty, required movements, amount of feedback provided, and degree of demands placed on participants. Major findings of the study indicated that suitable games for standing interventions in stroke populations require movements of the centre of gravity in different directions, provide multiple forms of biofeedback, and present the individual with additional forms of physical and cognitive demands. Five games were deemed suitable for individuals with severe standing impairment, six games were deemed suitable for individuals with moderate standing impairment, and nine games were deemed suitable for individuals with mild standing impairment. It was concluded that the Nintendo Wii™ and Nintendo Wii Fit Plus™ application provide a sufficient number of games and adequate level of biofeedback for rehabilitation of standing after stroke.

Finally, de Kloet, Berger, Verhoeven, van Stein Callenfels, and Vliet Vlieland (2012) used the Wii™ to explore its effects on the physical, social and cognitive function of 50 young adults with ABI, aged 6-29 years, using individually tailored interventions over a period of 12 weeks. This research was carried out with the involvement of physical and occupational therapists. De Kloet et al. found that participants improved in the amount of physical activity in which they could engage, in information processing ability, attention, response inhibition, and visual-motor coordination. De Kloet et al. (2012) cautioned that research using the Wii™ required development of a consensus on appropriate outcome measurement tools. They also recommended using a limited number of games in future research.

Although these research findings have contributed to an understanding of the effects of implementing the Nintendo Wii™ as a clinical rehabilitation tool among individuals with ABI much of this research has focused on acute rehabilitation following stroke. It is therefore not clearly established whether the aforementioned findings may be generalized to groups of individuals other than those with stroke, who received their ABI several years earlier from diverse etiological causes such as falls, motor vehicles accidents, or tumors. Moreover, provided that the majority of the aforementioned research has been carried out in formal rehabilitation settings (inpatient and outpatient), research is warranted to determine if implementing a training program based on the Wii™ system is feasible within a community setting without the presence of rehabilitation professionals.

The Present Study

The present study was designed as a feasibility study to investigate a potential strategy for recruitment of participants, procedures for implementation of a research protocol (including intervention duration, timing, and frequencies), safety considerations, population suitability, usability and efficacy of outcome measures, processes to enable adherence to the research protocol, and indications as to whether balance rehabilitation may occur in a sample of individuals with ABI other than stroke using an exercise program designed around the Nintendo Wii™ and Wii Balance Board™ system.

Purpose of the study.

The primary purpose of this study was to examine the feasibility of the Nintendo Wii™ and Wii Balance Board™ as an adjunctive tool to improve balance, in a 4-week community based exercise program for individuals living with ABI several years post injury. The secondary purpose of this study was to determine whether use of the Nintendo Wii™ may lead to clinically significant changes in occupational performance and/or community integration.

Research questions.

The present study has been designed to answer the following questions:

1) Is the Nintendo Wii™ an effective measure to improve balance among adults living with ABI (other than stroke) several years post injury in a community clubhouse setting?
2) Does implementing a Wii™ based intervention developed to improve balance lead to changes in occupational performance and/ or community integration?
3) What are participants' perceptions of the Nintendo Wii™?

Significance of the present study.

The significance of the present study rests with the beneficial impact that the results may have on several aspects of the ABI recovery process. For example, community agencies that assist adults living with ABI transition from post-acute rehabilitation into community settings (e.g., group homes or day programs) could utilize the study findings to help implement similar programs into their daily programing. In doing so, this could potentially afford members the opportunity to engage in rehabilitation that may support socialization and foster behaviours such as teamwork that are necessary to becoming productive in the community. Moreover, the findings of this study have the potential to demonstrate to participants that despite their injuries and or limitations, participating in a new activity (such as the Wii™) is possible. This in turn may motivate individuals to work towards enhancing their functional abilities, trying something new, becoming active in leisure and social activities, and ultimately becoming more involved as members of their community.

Chapter 2: Methods

Study Design

The current investigation was designed to be a feasibility study. The term “feasibility study” is often used synonymously with the term “pilot study” (Last, 2002; Thabane et al., 2010). Regardless of the terminology used, the purpose of a feasibility study is to conduct small-scale test of methods and procedures to be used in a larger study and as a means to determine whether a particular research strategy might find possible effects and associations that may warrant further exploration (Leon, Davis, & Kraemer, 2011; Thabane et al., 2010).

Study Sample

A total of eight individuals with Acquired Brain Injury (ABI) were recruited to participate in this study. Participants were recruited from a local day program which supports adults living with acquired brain injury in Southwestern Ontario. The community program works to help members regain self-worth, purpose and confidence, and help to raise knowledge and awareness of ABI within the community. To do the latter several supportive relationships with different community agencies have been formed such as the following, to name but a few: Parkwood Hospital a part of St. Joseph’s Health Care, Dale Brain Injury Services and Western University. The community program follows clubhouse model guidelines by adhering to the following standards of the International Brain Injury Clubhouse Alliance (IBICA, 2008): (1) Memberships, Relationships, and Space; (2) Work-ordered Day: facilitators and members engage in the operations of the community program through work units (lawn care, kitchen, administration), nature of activities undertaken, and daily working hours; (3) Employment and Education: assist members in employment and educational opportunities through ‘real-world’ experiences and feedback; (4) Functions of the House including: recreation and social activities; (5) Funding, Governance, and Administration: budgetary policies and procedures to engage stakeholders; which serve as a “Bill of Rights” for members and a code of ethics for staff. In addition the community program is the first to be accredited by the International Centre for Clubhouse Development (Vlope, 2012).

Further adhering to the clubhouse model, individuals associated with the community program are referred to as members rather than clients or patients, and each individual is recognized for his or her unique skills and abilities. Members have typically completed formal rehabilitation programs such as physical and occupational therapy. To become a member individuals must have sustained an ABI, be older than 18 years of age, pose no significant threats to others, and be willing to commit to a no substance use policy. Although community agencies or local hospital rehabilitation programs can refer individuals, a formal referral is not required. The environment of the program is directed and inspired by the belief that staff and members are to work together to keep the clubhouse functioning in order to achieve members' individual and collective goals (Vlope, 2012).

To accomplish this, the program is comprised of several units, each of which provides meaningful work for both members and staff. For example, members and staff work in unison to prepare meals, answer phones, manage correspondence, manage finances, receive guests, conduct tours, prepare newsletters, and maintain the local environment and grounds.

Recruitment strategy.

An information session was held at the community program explaining the purpose and aim of the study, expectations of participants, data collection methods, duration of the study, and the criteria for voluntary study participation. The information session also included a demonstration of the Nintendo Wii™ and games, and a question period wherein study investigators responded to any questions regarding the study (e.g., structure of the exercise program, how to play games and the main purpose of the study). Members from the day program were asked to consider participating if they experienced balance and stability issues that limited their occupational performance and/or had fears of falling.

In order to participate in this study, individuals were screened for eligibility by program staff, based on safety considerations through sn in house falls assessment and behavioural issues that had been logged in staff reports. Interested individuals who met the day program's criteria were asked to fill out a brief questionnaire pertaining to the length of time they had been with the day program, length of time since ABI, any perceived problems with balance, and how balance problems interfered with daily activities. Individuals were excluded from the study if they did not experience balance or stability issues or fears of falling that limited their occupational performance, if they had incurred their ABI within the last two years, and if they were under the age of 18. In total four females and three males agreed to participate. Participants' age ranged from 35 to 55 years, and time since injury ranged from 16 to 35 years. The research protocol, methods of recruitment and informed consent were approved by the Health Sciences Research Ethics Board, at Western University (Appendix A). All participants provided free and informed consent.

Testing Procedure

All testing took place at Day Program. Participants were assessed at two different time points throughout the course of this study: (1) baseline (within one week prior to starting the exercise program); and (2) post-intervention (within one week after completing the exercise program). The testing protocol as outlined below was the same at both time periods.

Baseline Testing Session

At the start of baseline testing, participants were asked to read the Letter of Information (Appendix B) describing the study and to sign a consent form (Appendix C) indicating they understood their responsibilities and were willing to participate. Participants were made aware of their right to withdraw from the study at any time and were encouraged to ask questions.

Upon providing informed consent, each participant had their balance, and balance confidence assessed on the Functional Reach Test (FRT) (Duncan, Weiner, Chandler, & Studenski, 1990) (Appendix D) Community Balance & Mobility Scale (CB&M) (Howe, Inness, Venturini, Williams, & Verrier, 2006) (Appendix E); and Activities-specific Balance Confidence Scale (ABC) (L. E. Powell & Myers, 1995) (Appendix F), respectively. In addition, participants were asked to complete the Community Integration Questionnaire (CIQ) (Willer, Ottenbacher, & Coad, 1994) (Appendix G), and to participate in a semi-structured interview wherein their occupational performance was assessed using several probing questions (Appendix H) and the Canadian Occupational Performance Measure (COPM) (Law et al. 1994) (Appendix I).

Functional Reach Test (Appendix D).

The Functional Reach Test was designed as a measure of dynamic balance that is simple to perform and easily accessible (Duncan et al., 1990). It defines the maximal distance one can reach forward beyond one's arm length, while maintaining a fixed base of support in a standing position (Duncan et al., 1990). It is performed by fixing a yard stick on the wall parallel to shoulder height. The individual is next asked to stand beside the yard stick, extend their arm while making a fist, and to reach as far forward as they can without losing their balance and without moving their feet or touching the wall. The distance between the initial starting position and final position of the metacarpals is determined to be an individual's functional reach score; measures are taken in inches.

Community Balance & Mobility Scale (CB&M) (Appendix E).

The CB&M scale is a 13 item test comprised of various tasks that would be commonly performed outside the clinical setting. Specifically, tasks mimic necessary motor skills needed to complete activities of daily living (ADL's) and to function within the community, including postural control while performing more than one task, sequencing of upper and lower limbs, and complex motor skills. The CB&M has been found to be a valid and reliable measure of balance for individuals with brain injury that can be used in both clinical and research settings (Howe et al., 2006).

Activities-specific Balance Confidence Scale (ABC) (Appendix F).

The ABC requires participants to rate their perceived level of confidence in their balance on a scale of 0% -100% for 16 functional tasks requiring balance, as for example, standing on tip toes to reach for something above your head or walking through a crowded mall (Powell & Myers, 1995). This measure has been found to be a valid and reliable measure of balance confidence (Teasell et al., 2010).

Community Integration Questionnaire (CIQ) (Appendix G).

Comprised of 15 questions, the CIQ is a brief measure of a participant's level of integration into the home and community following traumatic brain injury (Willer et al., 1994). This measure is considered the gold standard for determining functional outcome at the participatory level following brain injury (Zhang et al., 2002).

Canadian Occupational Performance Measure (COPM) (Appendix I).

In the COPM, participants are asked to select five activities that are most important to them and then to rate the difficulty they have with the activity and their satisfaction with their performance on a scale from 1 (great difficulty/not satisfied) to 10 (no difficulty/very satisfied) (Law et al. 1994). This measure has been identified as having adequate to excellent test re-test reliability and as a valuable tool in assisting in client centered rehabilitation (Cup, Scholte op Reimer, Thijssen, and van Kuyk-Minis, 2003; Eyssen, Beelen, Dedding, Cardol, and Dekker, 2005; Phipps and Richardson, 2007).

Intervention: Balance Training

Once all assessments were completed, participants were given an orientation to the Wii™ console, and given an opportunity to:

1. receive instruction on the use of the Wii™ console and peripherals (e.g., controller);
2. receive instruction (and see demonstrations of) the safe performance of each activity within the balance training protocol, including methods for grading the activity difficulty; and,
3. perform simple activities under the guidance and supervision of study investigator(s).

Participants were then asked to engage in 30 minutes of Wii™ based activities twice per week, for a total of 60 minutes of activity per week for 4 consecutive weeks. Each session was delivered in 15-minute intervals, such that participants would complete 15 minutes of Wii™ training, have a 15-20 minute break, and then complete another 15-minute training session. All sessions were held on site at the community program and delivered on a one-on-one basis with a member of the research team. Staff members of the community program were present during training sessions for safety. All activities included in the exercise program utilized the Balance Board™ accessory, and were from the video game Wii Fit Plus™, which focuses on physical fitness. Although this game includes several activities in each of the 4 fitness areas: yoga, strength training, aerobics, and balance the exercise program included only activities from the balance domain. Participants were given a series of exercises/games to do that had been previously screened by the researchers for their suitability for this study (i.e., they met a pre-determined set of criteria for safety). For example, participants were discouraged from trying the ski jump, snowboard, and yoga activities as these activities require the user to adopt positions and movements that may place them at an increased risk for a fall. To help sustain user interest, participants were free to select which balance activities they engaged in during each session from the selection of six games offered. Participants were encouraged to select a variety of games not just their favourite to offer a variety of challenges to their balance and to ensure they practiced weight shifting in each direction. Participants were provided with verbal instructions and hands on demonstrations highlighting how each of the included activities was to be accessed and played. A brief description of each balance activity is presented in (Table 1).

Table 1

Description of Balance Games

Game	Description
Balance Bubble	Participant directs a bubble by shifting their weight right or left down a winding river while trying to avoid the edges of the river. Shifting weight forward increases speed. Game ends when bubble reaches the end of the river, or when the bubble "pops" if it comes into contact with the side of the river.
Table Tilt	Participant shifts their weight right, left, forward and/or backward to tilt a table surface to direct a series of rolling balls into holes in the table. Difficulty level increases when each series of balls are successfully navigated into the holes. Game ends when time runs out.
Soccer Heading	Participant shifts weight right or left to head a series of soccer balls that are kicked at them while trying to avoid distracter objects (i.e., soccer cleats, panda heads). Game ends when time runs out.
Tightrope Tension	Participant walks in place while attempting to cross a tightrope. Participant must bend and extend knees to jump over obstacles. Game ends when participant falls off tightrope, reaches other side, or when time runs out.
Penguin Slide	Participant shifts their weight right or left to tilt an iceberg and slide a penguin back and forth to catch fish. Faster weight shift makes the iceberg toss the penguin up to catch fish worth more points. Game ends when time runs out.
Ski Slalom	Participant shifts their weight right and left to navigate through a series of gates on a slalom ski course. Game ends when the end of the course is reached.

Note. (Holmes et al., 2013)

Post -Training Testing Protocol

Within one week of having completed the 4-week exercise program, participants' were re-assessed on each of the outcome measures completed at baseline (CB&M, ABC, FRT, CIQ, and COPM). Each participant was also asked to take part in a semi-structured interview, following the completion of the exercise program and conducted by a member of the research team. Participants were asked to discuss their personal experiences using the Wii™ before, during, and after having completed the research protocol. Specifically, semi-structured questions (Appendix H) asked participants' to convey their experiences and feelings with questions pertaining to their likes and dislikes of the Wii™ system, comparison of the Wii™ to other exercise programs, perceived effects on balance or abilities to do things as a result of participation, interest in continuing use of the Wii™ or whether they thought there had been lasting changes following participation in the present study. This latter component of the study was incorporated into the research protocol as Finlay and Ballinger (2006) report that the use of both quantitative and qualitative methodologies can serve to achieve mutual validation of results and/or create a fuller more complementary picture of a phenomenon.

Quantitative Statistical Analysis

All quantitative statistical analyses were completed using the Statistical Package for the Social Sciences (SPSS) version 20. To evaluate the effect of the Wii™ training program on balance, community integration, and occupational performance, three within subject multivariate analyses of variance were conducted. For each analysis the within subject factor was time with two levels (baseline, post-intervention), and the three dependent variables for each of the aforementioned domains were as follows: i) Balance (FRT, ABC, and mCB&M scores); ii) Community integration (home, social, and productivity sub-scores); and iii) Occupational performance (satisfaction and performance ratings). Multivariate analyses were determined to be the most appropriate analyses to run (in comparison to several t-tests) as this type of analysis controls for the potential increase in the number of Type I errors that may occur when multiple statistical comparisons are made (Hummel and Sligo, 1971).

Qualitative Data Analysis

A directed content analysis approach as discussed by Hsieh and Shannon (2005) was selected as an appropriate method to analyze data collected from semi-structured interviews. In this approach, researchers identify initial coding categories on the basis of key concepts or theory that is based on prior research (Hsieh & Shannon, 2005). It was decided that, based on existing evidence regarding the use of the Wii™ as a therapeutic intervention (Brown et al., 2009; Celinder & Peoples, 2012; Gil-Gomez et al., 2011; Lange et al., 2010; Meldrum et al., 2012; Thornton et al., 2005; Yip & Man, 2009), data would be coded from the following predetermined categories: satisfaction; use of Wii™; balance; duration, frequency and timing of sessions; and daily living (e.g. use of Wii™, independent use of Wii™).

Semi-structured interview responses were recorded by hand on the day of the interview as participants were uncomfortable with the use of recording devices. In order to reduce bias and ensure trustworthiness of the analysis of participant's interviews, an audit trail was kept of transcripts and content analysis. The transcripts, audit trail and content analysis were reviewed and discussed with one of the co-supervisors for the thesis to ensure veracity, and as much neutrality as possible. Hand written interview transcripts for each participant were then typed into Microsoft Word 2010. Participants were assigned unique identifiers to protect their confidentiality (P01, P02, etc.) and interview transcripts were titled and saved under participant's assigned identifiers. For each transcript participants' responses, interview questions and researchers' comments were differentiated by different colored fonts. Each interview transcript was coded for the pre-determined categories (balance, duration of sessions, frequency of sessions, timing of sessions, satisfaction with participation, effect on daily living, and general comments regarding the use of the Wii™). Each coded category was then categorized as representing a positive response (i.e., indicating an improvement in perceived balance, or liking the duration and frequency of sessions, etc.) or negative (i.e. indicating no perceived improvement or lack of satisfaction with the research protocol, etc.).

Chapter 3: Results

The purpose of this study was to evaluate the feasibility of a 4-week community based exercise program designed around the Nintendo Wii™ as a method to improve balance among individuals with ABI and to determine whether the use of the Wii™ might translate into clinically significant changes in occupational performance and/or community integration. While eight participants were originally enrolled in this study, one participant (P06) had to withdraw after baseline data was collected because they were unavailable on the days on which the exercise program was scheduled to run. As a result, data were analyzed from a total sample of seven participants. Of the seven participants, it is also important to note that one participant (P04) was visually impaired. Specifically, this participant was diagnosed with cortical visual impairment, a neurological disorder resulting in temporary or permanent vision loss caused by damage to the visual cortex or posterior visual pathways (Watson, Orel-Bixler, & Haegerstrom-Portnoy, 2010). Functionally, this participant reported that as a result of their visual impairment they experience difficulty with spatial orientation, the detection of movement, and with accurately recognizing objects and shapes. To compensate for these impairments in the present study, the television and Wii™ system were positioned close to the participant and off to one side such that they could be viewed with the less impaired peripheral vision. In addition, all Wii™ training for this participant was completed with the lights in the room dimmed to produce greater contrast, and verbal cues were provided by investigators when needed (e.g., lean left, lean right, focus on the top of the screen). These modifications, assisted P04 to better identify movements and actions on the television screen, and directed their attention to important features of the Wii™ activities.

Qualitative Feedback

As indicated in the Methods' section, participant's experiences and feelings with the Nintendo Wii™ and Wii Balance Board™ over the course of the current study were explored using open-ended questions (Appendix H). It must be pointed out that persons with acquired brain injury are known to have communication difficulties that may cause them to respond to open-ended questions in a concrete and limited manner (Carlsson, Paterson, Scott-Findlay, Ehnfors, & Ehrenberg, 2007; Rousseaux, Verigneaux, & Kozlowski, 2010). That was the experience in this research. Qualitative data obtained from participants was limited in scope and content and it proved difficult/ impossible to elicit rich, in-depth information from participants as a result of their communication constraints, even when probing questions were used in addition to the open-ended questions in the interview guide.

Satisfaction.

Within the category "Satisfaction", interviews revealed that participants were delighted with what they accomplished as they played the Wii™ games and surpassed what they thought they could do. For example: P04, who is also visually impaired, found that through participating, he/she was able to try something different, be successful at it, and become more confident: "built up my confidence. I'm successful at trying new things. Feel I can try new things now, feel good about it". Other participants had similar experiences: P05, "something never done before," and P07, "did something that I have never thought I would do."

Secondly, participants were very proud of what they accomplished. P05 described: "I was proud about what I did with some of the games,"; "proud of seeing how well I could do the next time," and P07, "yeah, when I did really well I remember walking out with a smile." Furthermore participants enjoyed themselves and were motivated to do better each time, as described by: P03, "liked it- trying to see if I could get better," and P08 "I felt good doing it, did want to work to do better next time."

Though participants all felt satisfied with their engagement and improvements, some participants did report having moments which they found to be upsetting: for example P02 and P05 found distractions difficult: P02, "a facilitator would come in and distract me and upset me and I would do worse" and P05 "facilitator would interrupt- I would mess up- I would tell him/her to get out because he/she would talk and distract me." As well, some participants reported being displeased with their performance P04, "didn't do good on soccer as I could."

Use of Wii™.

In the category "Use of Wii™", all seven participants voiced strong positive feedback about the Wii™ and the exercise program, for example: P01, "I like the setup," "table tilt was fun," "soccer game was fun," P03, "really liked the table tilt wanted to see how far could go in levels," P04, "penguin- I could see the blue fish better than the other ones," P05, "the games were fun. Soccer was good- (people I worked with were fun). The skiing was good," "easier and more fun," "I liked it, thought it was fun," "yes! It's fun. I like to do it, can do with others and compete. Set a goal compete with yourself or others," P07, "really enjoyed it," "I liked everything about it," and P08, "just really like the penguin slide". Participant enjoyment with the Wii™ exercise program was evidenced as the majority of participants attended all training sessions (Table 2). The three participants who did not attend all training sessions were unable to do so secondary to a variety of reasons including unforeseen personal circumstances unrelated to the study protocol and forgetting about their scheduled training.

Table 2.

Training Session Attendance.

Participant Number	Number of Sessions Attended (Max 8)
P01	8/8
P02	7/8
P03	8/8
P04	8/8
P05	6/8
P07	5/8
P08	8/8

Interviews revealed that three participants found the Wii™ to be a fun alternative to traditional therapy methods which could be found to be a chore: P03, "had physical therapy- push bar- use your body. Used different body- did not realize using own body because interacting with game," P05, "usual exercise seems like a chore, this is fun and look forward to doing," and P07, "had OT and would definitely take this over it". As well, one participant liked the freedom they felt when using the Wii™: P02, "it is not someone else grading me it is myself grading me which is very nice to have."

Furthermore, most participants felt a positive impact from the use of the Wii™ on their independence: P02,"I like the independence that it gives me," P04, "gives me more independence," "gives me self-esteem," P05, "can see independence, because doing it on your own no one helping you," "I felt independent," and P08, "felt more independent".
However, two participants, did not feel an impact on their independence: P07 stated: "I think I have always felt fairly independent," and while (P02) did feel more independent when using the Wii™, he/she also stated "I do not completely trust myself independently…. Only fear is that it would be in my house and I would be too competitive with myself and risking myself."
Overall, participants liked the games, and selected certain games as favorites: P01 and P03 preferred Table Tilt, P01 and P05 liked Soccer Heading, P08 and P03 liked Penguin Slide and P05 and P07 enjoyed Downhill Skiing. Three participants avoided certain games because they were either too easy or too difficult: P01, "there were levels - Penguins were easy and others got harder," P03, "visually walking on the screen was different than what needed to be done on the Balance Board™," and P08, "tightrope was tough! Had to balance self on screen and balance self on board and that was hard." It was also found that one participant (P01) would have liked more interesting games: "could of spiced up games," "need an array of different things to learn .Mentality, achievement- just wanted to try different things."

Balance.

Within the category "Balance", only P07 reported that he/she experienced an improvement in balance: "do (other exercise)-balance positions have been easier to do." Nevertheless, when asked in the interview "has participation in this study affected your balance?"

P07 responded positively “yes I think so – [on] (other exercise) poses, can do the balance positions better,” attributing improvement to use of the Wii™. However, other participants were unable to identify changes and/or improvements in their balance. For example: P02, “I did not see improvements,” P05, “don’t think it has”; and P08, “not really”.

Despite the majority of participants not perceiving improvements in balance, two participants did indicate that with further use of the Wii™ they thought their balance could improve: P02, “I can see myself and balance improving with it,” and P05, “but time will tell as well it is exercise”.

Duration, frequency and timing of Sessions.

Frequency of sessions.

In the category “Frequency of Sessions”, the majority of participants had neither positive nor negative comments. This might be interpreted as strength, in that participants were content with how often they engaged with the exercise program and that therefore, using the Wii™ two out of seven days per week is a reasonable amount of time when introducing an exercise program such as this. However, P02 did want the frequency of sessions to be more than two days a week:

> I am very competitive with myself and I was only able to do it two times a week… With someone who has such balance issues I need it to be more often and repetitive… If I could do it more I believe I could see improvements.

Length of sessions.

Within the category “Length of Sessions”, interviews aided in the discovery that participants were unhappy with aspects of the timed sessions. Several participants reported wanting more time engaging with the Wii™ before a break was needed: P02, “study was too short- would like to do 30 minutes straight; think it is better,” P03, “Time too short – just a ‘tease,” and P07, “the time limit I had to be on it- awe 15 minutes already up.”

Participants' reasoning is that by the end of the first 15 minute interval they just became comfortable with the Wii™, Balance Board™ and games but then it would be time for a break and they would have to work to that level of comfort again in their next 15 minute session:

> You know my body takes longer to get into the motions and mode- having a break at 15 minutes stopped the peak time in which I started to be more comfortable and better at the games. I would be getting good and then told to stop because time up (P02) and

P03, "beginning sucked, by the end you get good and it's done- break time."

Several participants felt that the allotted time frame of 4 weeks was too short: P05,"with enough time I think 4 weeks is not enough time to evaluate," P03, "process was not long enough- wanted to play with games longer", and P02, "Cannot tell with the short time frame- need more time."

Timing of sessions.

Within the category "Timing of Sessions", interviews aided in establishing that some participants were unhappy with the time of day in which exercise sessions were held. Participants described several reasons why they were dissatisfied with the timing of the sessions: P02 felt constrained by the afternoon sessions: "only thing I disliked is that I had to do it at a certain time, not at my leisure time." P02 indicated: "the morning … that's when I have energy …I had to do it at the end of the day which is worse for me."

P04 and P05 agreed with P02 that the time of day was too late but for different reasons: P04 found it to be too late because it was past their dinner: "waiting for turn was long; 6pm--past dinner time," and P05, found it too late because the late afternoon is when they go to bed: "so late; usually sleeping". It is important to note that for this research, sessions were held in the late afternoon. This time of day was dictated by scheduling constraints of the community program (e.g., needed to be held between 4 and 6pm in order to avoid interfering with other scheduled activities within the community program environment).

Daily living.

In the category "Daily Living", only P07 found that participation led to a difference in his/her daily routine and activities: "I have been doing the work-out routine more…Getting through my exercises faster and able to do my (exercise) poses better--experience those benefits." Most participants noticed no difference in either daily activities or routines: P08, "daily activities stayed the same; no changes," P01, "have not felt an effect of activities or ability to do things since study," and P03, "no changes, nothing to add to activities."

Participants did think this was a fun activity, which they would like to continue: P02, "I would like to do the Wii™ and games more often" and felt there might be lasting changes from participating: P01, "there might be," P07, "yeah, I think so," and P08, "I think I will remember what I have learned: when bending down to pick something up; getting in and out of the car."

Quantitative Results

Balance.

Balance of each participant in this study was initially going to be assessed using the CB&M, FRT, and ABC. However, due to space restrictions, and safety concerns, the decision was made that modifications to the CB&M measure were necessary. Specifically, the CB&M was tailored for this study to exclude tasks that were considered unsafe for participants (i.e. tasks were taken out of the CB&M if, in consultation with staff at the community program, these tasks were considered to place participants at risk for a fall). The modified version of the CB&M (mCB&M) included the following three tasks: unilateral stance, left and right leg stance, and tandem walking.

To evaluate the effect of the Wii™ training program on balance, a within subject multivariate analysis of variance was conducted. The within subject factor was time, with two levels (baseline and post-intervention), and the dependent variables were FRT Scores, ABC Scores, and mCB&M scores. Specifically, the multivariate effect of time was tested using Wilk's lambda. Results were found to be non-significant (Wilks's λ =0.28, $F(5,2)$ =1.05 , p=0.555), thus indicating that the training program did not lead to significant improvements in the omnibus domain of balance. Baseline and post-measures are presented in (Figure 1; Figure 2; Figure 3).

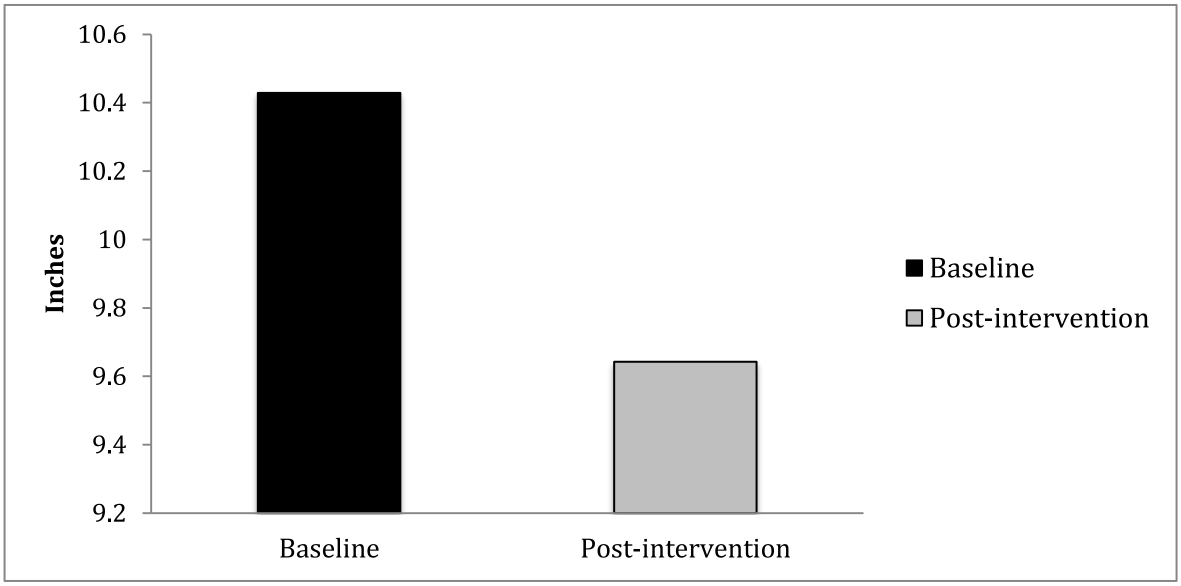

Figure 1. FRT Measures for Participants at Baseline and Post-Intervention (4-weeks).

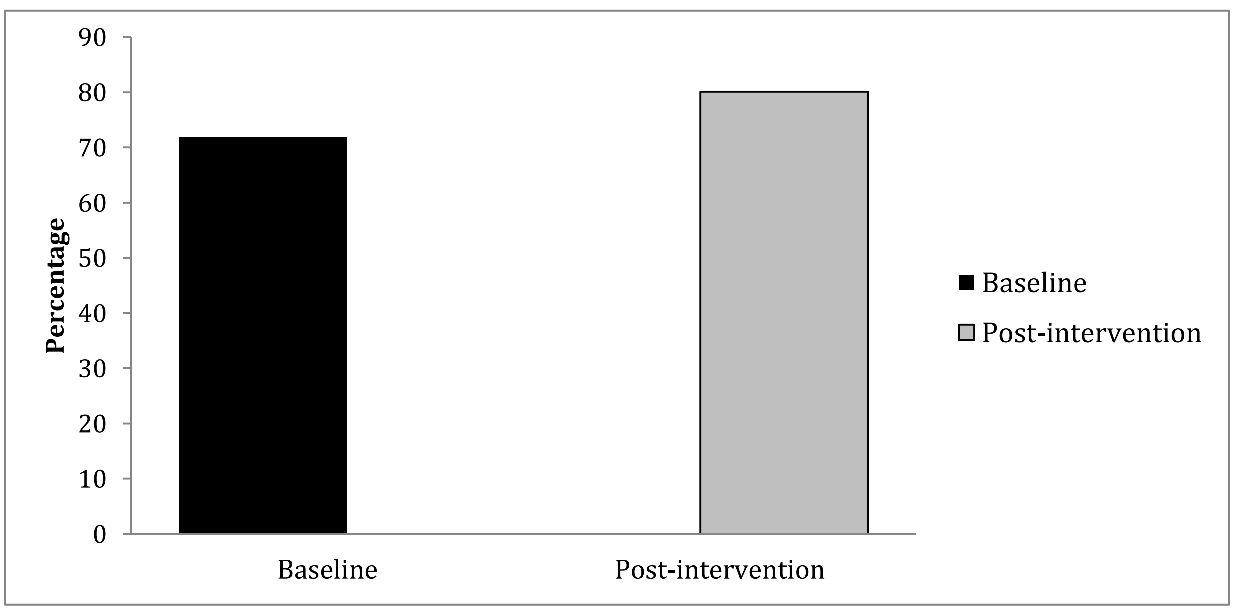

Figure 2. ABC Scale Scores for Participants at Baseline and Post-Intervention (4-weeks).

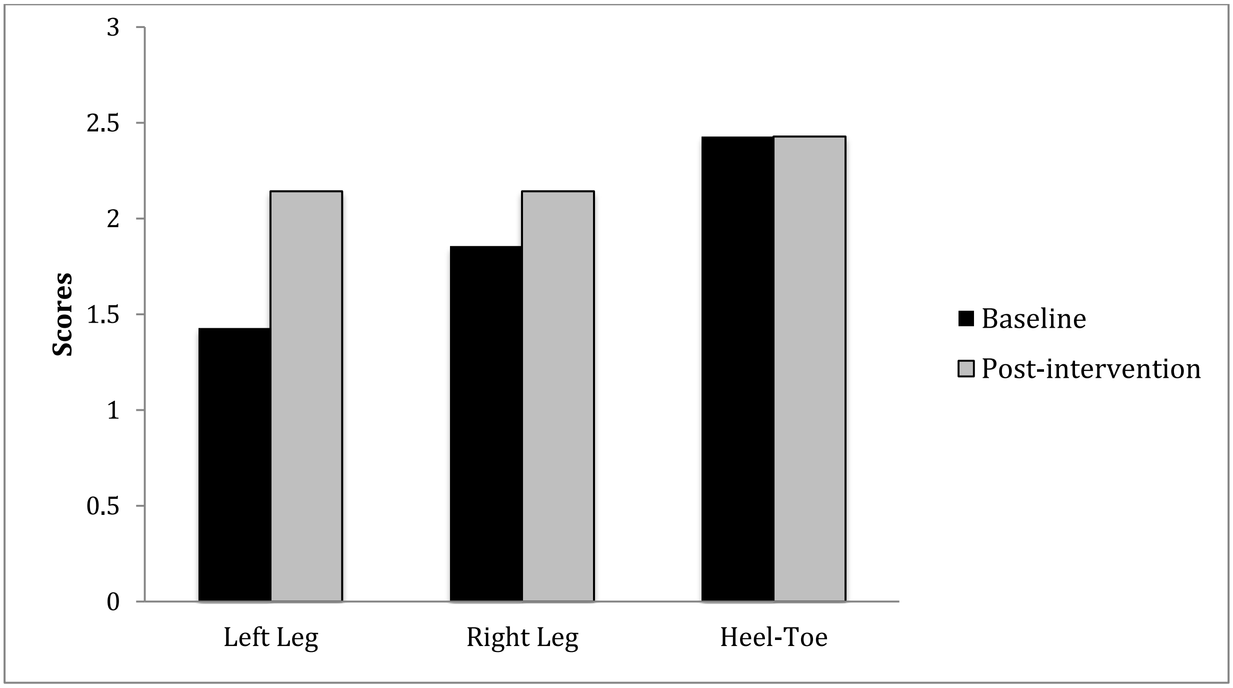

Figure 3. m-CBM scale scores for participants at baseline and post-intervention (4-weeks).

Community integration.

To evaluate the effect of the Wii™ training program on community integration, a within subject multivariate analysis of variance was conducted. The within subject factor was time, with two levels (baseline and post-intervention), and the dependent variables were home, social, and productivity subscores. Specifically, the multivariate effect of time was tested using Wilk's lambda. Results were found to be non-significant (Wilks's λ =.58, $F(3,4)$ =0.95 , p=0.497), thus indicating that the training program did not lead to significant improvements in the omnibus domain of community integration. Baseline and post-measures are presented in (Figure 4).

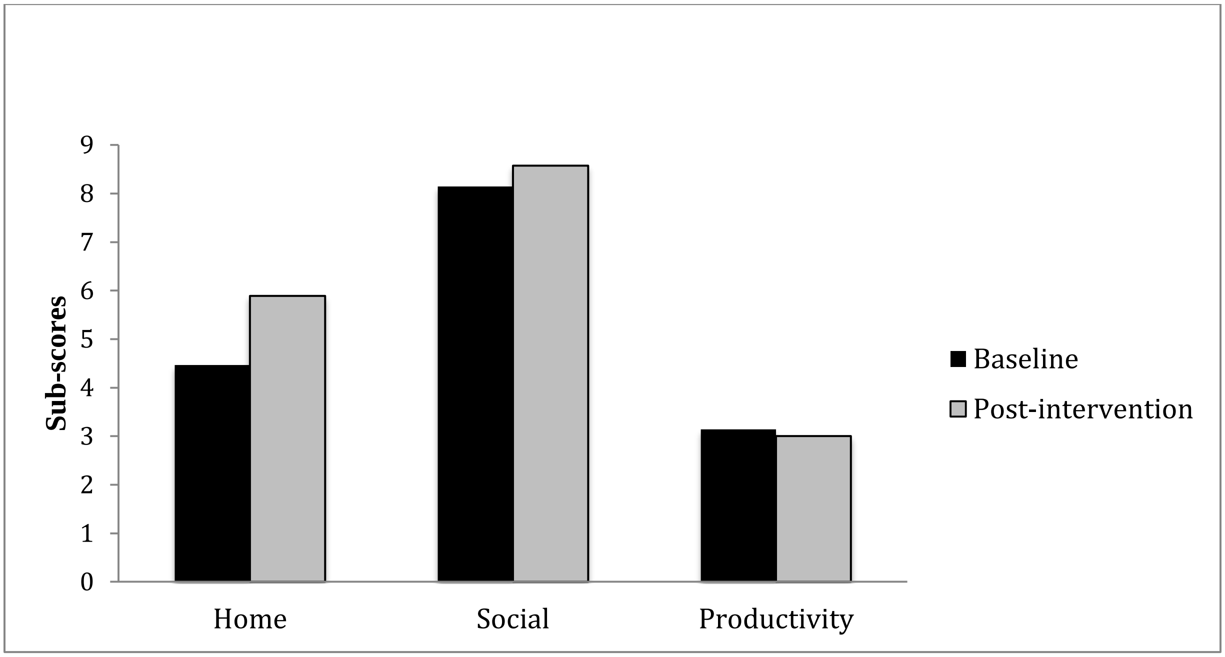

Figure 4. CIQ measures for participants at baseline and post-intervention (4weeks).

Occupational performance.

To evaluate the effect of the Wii™ training program on occupational performance, a within subject multivariate analysis of variance was conducted. The within subject factor was time, with two levels (baseline and post-intervention), and the dependent variables were performance and satisfaction sub-scores. Specifically, the multivariate effect of time was tested using Wilk's lambda. Results were found to be non-significant (Wilks's λ =0.37, F(2,5) =4.18 , p=0.086), thus indicating that the training program did not lead to significant improvements in the omnibus domain of occupational performance. However given that the results were found to approach significance, a decision was made to explore the univariate effects for each dependent variable separately. Each of the univariate analyses were done using the Greenhouse-Geisser Epsilon Correction for lack of sphericity. In addition, given that the multivariate effect failed to reach significance, a Bonferoni Correction was applied to control for multiple comparison bias. The univariate tests of significance were compared against an adjusted alpha of .025. The results of the ANOVA for satisfaction were non-significant [F(1,6) =1.76, p=0.233], whereas the results of the ANOVA for performance were significant [F(1,6) =9.99, p=0.020]. Baseline and post-intervention measures are presented in (Figure 5)

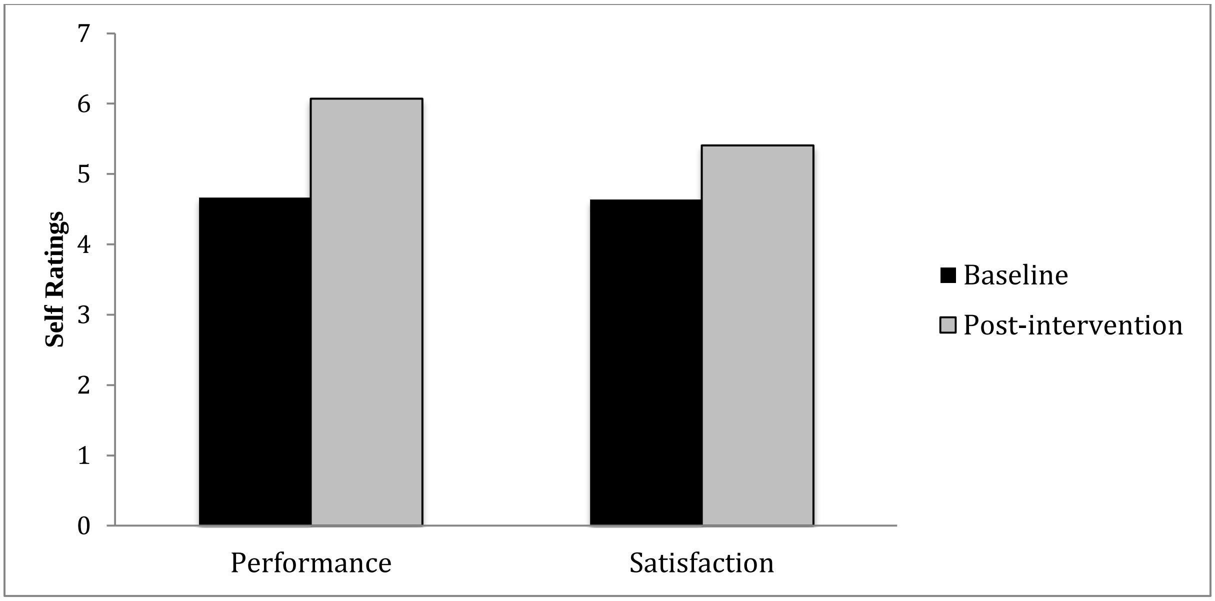

Figure 5. COPM measures for participants at baseline and post-intervention (4-weeks).

Chapter 4: Discussion

The primary purpose of this study was to examine the feasibility of the Nintendo Wii™ and Wii Balance Board™ as an adjunctive tool to improve balance, in a 4-week community based exercise program for individuals living with ABI several years post injury. It was also the purpose of this study to determine whether use of the Nintendo Wii™ to improve balance could be translated into clinically significant changes in occupational performance and/or community integration. This chapter will discuss results of the current study in relation to the objectives of the study and in comparison to previous research.

Feasibility of Implementing the Nintendo Wii™ within an ABI Community Clubhouse Setting

As discussed in the literature review, the Nintendo Wii™ has previously been examined as a clinical rehabilitation tool for improving balance within several diverse populations, including ABI. In general, findings suggest that in comparison to conventional therapy that has been noted by Berger et al. (2012) to be a tenuous process, and often discontinued due to a lack of user interest, the Wii™ is capable of producing lasting motor changes in a fun environment that is both motivating and engaging. For example, Gil-Gomez et al. (2011) successfully demonstrated that the Wii™ could be implemented within a rehabilitation program designed to improve balance among individuals living with ABI. Similar positive findings were also reported by de Kloet et al. (2012) and Ding et al. (2013) both of whom examined the utility of the Wii™ among individuals living with a brain injury. Although previous research in this area has increased our understanding of the utility of implementing VR into ABI rehabilitation, much of this research has been carried out in either inpatient or outpatient settings, and among individuals who recently experienced a stroke (e.g., within the last 6 month). While these positive findings are encouraging, future research is warranted to examine whether similar Wii™ based intervention programs could be effectively delivered without the presence of therapists within a community setting among individuals who experienced a variety of ABI's (not only stroke), several years post injury.

The findings of this study suggest that overall; the Nintendo Wii™ is a feasible option that could be introduced into a community clubhouse setting as a means to help members improve their balance. The proceeding section will discuss aspects of study feasibility within the following dimensions: participant adherence, program delivery (time of day, duration and frequency of intervention), and methodological considerations.

Participant adherence.

An important finding of the current study is that the Wii™ exercise program was able to sustain user interest. This was demonstrated as the majority of participants completed the required number of training sessions (eight) over the course of the study (2/week x4weeks). Motivation and enjoyment are two key factors that have been found to help foster adherence in exercise programs (Dault & Dugas, 2002; Gil-Gomez et al., 2011; Meldrum et al., 2012; Thornton et al., 2005; Yip & Man, 2009). In the current study several participants reported that they enjoyed participating in the exercise sessions using the Wii™ console and Balance Board™, thus it is likely this contributed to the high level of adherence demonstrated. This finding is consistent with results reported by Meldrum et al. (2012) who assessed the usability of the Nintendo Wii Fit Plus™ balance games for individuals with balance impairments caused by vestibular or neurological diseases. In their study, participants also reported very high levels of enjoyment and usability when using balance games with 73% of participants reporting more motivation and enjoyment than with traditional therapy.

Another factor that may have contributed to the high levels of adherence experienced could be related to the way in which the exercise program was scheduled to work around preexisting activities within the clubhouse model. Specifically, evidence suggests that in order to maintain user interest, exercise programs should focus on integrating training into participants' everyday life in a manner that they unite to produce a new life style (Meldrum et al., 2012). Given that the community program offers meaningful work and activities that are an integral part of the members' everyday life, the exercise program may have been received by members as being just another activity that makes up their daily routine. It is important to note that in order to facilitate the integration of the Wii™ program into participants daily routine, the timing of sessions were arranged in order to not interfere with regular activities within the community program such that participants would not be faced with the decision to attend their regularly scheduled activity, or participate in the exercise sessions. In doing so, it is believed that the Wii™ program was embraced by participants to be an integral activity within their daily routine, rather than being viewed as an "add on" to conventional programing. Thus it is possible that the organization of exercise sessions to fit into the flow and routine of both participants and day program may have helped participants to remain engaged in the exercise program over the 4-week intervention. Although in general adherence levels were favorable within this study, three participants failed to attend one or more of their scheduled training sessions. One reason that was provided to account for these missed appointments was related to impairments in memory (i.e., forgetting to attend the session). In the future, programs of this nature may benefit from incorporating frequent reminders to participants about their scheduled appointments. For example, this may involve calling or emailing the participants the day before to remind them of their commitment, or might include setting up reminder notifications on a device such as a smart phone or tablet, to remind the participant throughout the course of the day (i.e., 1 hour prior to training session).

Program delivery.

While measures were taken to ensure that the intervention was delivered at a time that would not interfere with regular scheduled activities, it is interesting to note that not all participants were satisfied with the timing of the intervention. This was evidenced as qualitative data revealed that participants would have preferred to have more individual control throughout the exercise intervention. For example, three participants P02, P04 and P05 noted that they would like to have had the option to participate in the exercise sessions earlier in the day as late afternoons have an effect on energy levels, sleep routines, and dinner schedules. Additionally, P02 considered dropping out following his/her first session from feeling physically and mentally fatigued due to the time of day (late afternoon) the intervention was offered. Similarly, P04 and P05 also expressed concerns with the timing of the intervention suggesting that it was offered too late in the day because this is when they would typically be finishing dinner and getting ready for bed. While the best time of day to deliver an intervention of this nature bears further consideration, it is important to note that most, if not all-traditional forms of therapist driven rehabilitation, are also faced with constraints associated with the timing of service delivery. Moreover, individuals in the current study were only provided with the opportunity to engage in Wii™ activities during “research hours”. In the future, if members of the community program were interested in making the Wii™ a permanent activity, the Wii™ could be set up in a space that would allow members the opportunity to engage in Wii™ based activity at their leisure.

In addition to feedback received regarding the time of day that the intervention was offered, participants provided feedback concerning the timing of rest breaks that were incorporated into each exercise session. Specifically, participants indicated that they did not like the fact that a rest break was mandatory at the halfway point (15 minutes), instead they would have preferred to have the option to skip breaks and play for 30 minutes straight. One reason that may account for why some participants were discontent with taking breaks could be related to the time it takes a person to settle into an activity. This is evidenced as one participant discussed how he/she felt breaks inhibited his/her ability to become comfortable with his/her body and the Wii Balance Board™. For example, P02 shared the following “…my body takes longer to get into the motions and mode- having a break at fifteen minutes stopped the peak time in which I started to be more comfortable and better at the game. I would be getting good and then told to stop because time up”. Other participants shared similar views P03 “beginning sucked, by the end you get good and it’s done- break time” and P07 “time limit I had to be on- awe fifteen minutes already up”.

From this feedback, it seems reasonable to suggest that future research of this nature may not need to incorporate mandated rest breaks in the study protocol. However, one should be cognizant that the decision to enforce rest breaks in the current investigation was made based on concerns related to the potential for participants to unintentionally overexert themselves and become fatigued. These concerns were raised as previous research with the Nintendo Wii™ has identified that participants report feeling high levels of motivation and enjoyment when engaged in Wii™ based activities (Meldrum et al., 2012). Although, this is one of the primary benefits to using the Wii™ in a rehabilitation context, caution is required as participants may enter a state of flow, wherein they become so completely engaged in the activity they lose touch with the situation around them (Reid, 2011). To this regard it was thought that if participants became "caught up in the action" they may have been less likely to self-identify that a break was required, and therefore run the risk of injuring themselves or becoming fatigued, both of which have been associated with diminished levels of exercise adherence (Jack, McLean, Moffett, & Gardiner, 2010).

Although participants were encouraged to self-select the games/activities that they engaged in over the course of the intervention, qualitative data revealed that participants would have preferred additional individual control. This became evident as some participants revealed that they felt limited by being restricted to only being able to select from specific activities in the balance domain of the game Wii Fit Plus™. For example, several times throughout the course of the study participants questioned why they could not play a certain game from the Wii Fit™ game menu or choose from a larger selection of games. The methodological decision to partially restrict the games which participants were permitted to play is in contrast to that of some previous research in this area. For example, Williams et al. (2011) permitted participants to have free choice of balance and aerobic games offered within the Wii Fit™ Plus package, whereas Hertz (2009) asked participants to engage in a variety of activities from the Wii Sports™ games including boxing and tennis which do not involve the Balance Board™ accessory. As a compromise, Esculier, Vaudrin, Beriault, Gagnon, and Tremblay (2012) asked participants to engage in a combination of activities from both the Wii Sports™ game and various Wii Fit Plus™ activities for which only some require use of the Balance Board™.

In the current study, the decision to restrict the games which participants were permitted to play was made as a means to facilitate participant safety and to foster improvement in balance. For example, the activities permitted in the current study (i.e., table tilt, ski slalom, balance bubble, soccer heading, tight rope, and penguin slide) require the user to make slow controlled movements while confined to standing on a Wii Balance Board™, whereas the activities associated with other games such as Wii Sports™ tend to focus on rapid powerful movements in an open environment that have been reported to lead to injuries. For example, in a study that assessed the use of the Wii™ in addition to conventional rehabilitation for individuals recovering from stroke, five cases of adverse events occurred. Specifically, two participants experienced immediate fatigue and lethargy from playing the Wii™, and following 96 Wii™ sessions, three out of 20 participants complained of mild pain and upper limb soreness (Joo et al., 2010). Similarly, it has been suggested that individuals can become so engaged with their game that they become unaware of their physical surroundings, which can then lead to falls and fractures (Shubert, 2010). Thus by having participants refrain from engaging in quick powerful movements with the Wii™ controller, and having them remain standing on the Wii Balance Board™ for all games, the risk associated with injury by the aforementioned means was reduced. Moreover, given that the intention of this exercise program was mainly to facilitate improvements in balance, it seemed reasonable to only use games that provided participants with the opportunity to engage in activities that were largely centered around learning how to shift weight forwards-backwards, and side-to-side. A similar methodological approach was employed by Ding et al. (2013) who delivered a Wii™ training program to improve balance among three individuals with chronic hemiparesis subsequent to stroke. In their study, Wii™ training was primarily restricted to the "Ski slalom" game as authors reported this game encouraged participants to weight shift in both the medial lateral and anterior posterior directions.

Another indicator to suggest that participants would liked to have had additional individual control over the delivery of the intervention came from several participants who identified that they would have preferred to have the exercise program continue longer than 4-weeks. For example: P01 stated "think it should not of been 4-weeks"; P02, "Cannot tell with the short time frame-need more time"; P03, "process was not long enough- wanted to play with games longer", and P04, "four weeks is not enough time". In addition, feedback was received from one participant suggesting that the number of sessions per week could be increased, P02, "it was only twice a week. With someone who has such balance issues I need it to be more often and more repetitive". Although some previous research has reported success in delivering Wii™ based programs over a longer period of time (i.e., 12 weeks; de Kloet et al., 2012), the decision to deliver the current intervention over a relatively short time period (i.e., four weeks) was based on research that identified rehabilitation programs lasting 2-3 weeks resulted in greater adherence rates that in comparison to programs lasting 5-6 weeks (Alexandre, Nordin, Hiebert, & Campello, 2002). Moreover, two recent publications that utilized the Wii™ as a rehabilitation tool among individuals with ABI also selected shorter time periods in which to deliver their intervention. For example, Celinder and Peoples (2012) examined the utility of a 3 week Wii™ exercise intervention consisting of three 40 minute sessions per week, whereas Ding et al. (2013) examined a week long Wii™ intervention that was delivered one hour per day over five consecutive days.

Methodological considerations.

Participants in the current study participated in semi-structured interviews following post-measures, to obtain participant perspectives; however, data collected from participants was limited in scope and content. This may be due to communication difficulties such as: participating in conversation (finding the right word to express oneself); talking at length; formulating sentences; and identification of people and/or objects (MacDonald & Wiseman-Hakes, 2010). Communication difficulties are common among individuals with ABI and may cause them to respond to open-ended questions in a concrete and limited manner (Rousseaux et al., 2010). Rousseaux et al. (2010) explain that individuals with ABI are affected in both non-verbal and verbal communication; limitations in conversation are often affected by various verbal communication difficulties such as speech flow, language pragmatics, producing fluent and intelligible language, and introduction of new topics to a conversation (Angeleri, Bosco, Zettin, Sacco, Cole, 2008; Bara, Tirassa, Zettin, 1997; Friedland & Miller, 1998). Speech and language pragmatics are often the most debilitating to carrying on a conversation as output of speech is associated with weak interaction skills and responding to open-ended questions is more difficult than closed questions. This was the experience in the current study as it was found close to impossible to illicit rich, in-depth information from open ended questions asked of participants, even when probing questions were used along with interview questions.

Fatigue is a second possible factor that may have contributed to the paucity of information gathered from participants during the semi-structured interviews. Common in the lives of individuals with ABI, participant fatigue may have led to communication difficulties in interviews such that participants responded with brief fragmented responses or potentially misinterpreted the researchers’ questions (Carlsson et al., 2007). For example, P01 was asked if the use of the Wii Balance Board™ make him/her aware of balance issues they previously were unaware of/didn't know about. P01 stated "I could do some of it but, some I could not- so balance some bad" demonstrating misinterpretation of said question as well as brief responses. In addition participants' responses in the current study: P01 "No", P01 "Table tilt was fun", P01 "Yea"; P03 "Same routine"… "No changes, nothing to add to activities", P03 "No"; P08 "Not really"; P05 "I liked it, thought it was fun"… "Liked it, Looked forward to doing it" are similar to Carlsson et al.'s (2007) findings that in interviews with individuals with TBI, assessing communication impairments, responses were often disjointed and fragmented. Future studies using semi-structured interviews to illicit richer data from participants should consider shorter interview lengths (30 minutes), fewer questions in one session, conduct several sessions over a period of time and review transcripts to identify topics that could be developed more at another interview session (Carlsson et al., 2007). Despite the fact that communication difficulties in semi-structured interviews may have hindered the acquisition of rich data, the information that was provided importantly denotes high user interest, enjoyment, and usability within this sample, and effectively displays trends of improvement in balance and occupational performance.

Quantitative Study Results

Improvement trends in balance and confidence.

Results of the present study found there to be no statistically significant improvement in the measures of balance (FRT, mCB&M), and balance confidence (ABC). However, a trend of improvement over time did emerge for both the mCB&M and the ABC. Overall scores on the mCB&M improved 1 point, and confidence scores on the ABC increased for 6 out of 7 participants. This is consistent with findings of previous research, which did not find significant improvements but rather reported trends of improvement. For example, Bainbridge et al. (2011) conducted a 6-week exercise program with community dwelling older adults with balance deficits that consisted of 30 minutes of Wii Fit™ activities, twice a week. While no statistically significant differences were identified for outcome measures used by Bainbridge et al. (2011), a trend of balance improvement was noted for 4 out of 6 participants on the Berg Balance Scale (BBS) and balance confidence improved in 3 out of 6 participants on the ABC. Trends of improvement were also reported by Thornton et al. (2005) within a sample of individuals living with a TBI wherein both functional balance and balance confidence improved over the course of a 6-week VR based balance exercise program, consisting of three 50 minute sessions per week.

In contrast to the observed trends for improvement among the mCB&M and ABC, the FRT scores at the post intervention time period were found to be lower than what were reported at baseline, thus suggesting that balance decreased over the course of the intervention. Several possible reasons could account for this unexpected finding. First, over-confidence and risk-taking are common among individuals who have sustained a brain injury (Giacino & Cicerone, 1998; Kennedy, 2001), and both behaviours could potentially explain higher scores at baseline. For example, prior to participating in the Wii Fit™ balance games, study participants may have been over confident in their abilities to balance and may have taken more than optimal risk while originally performing the FRT. However, through engagement with the Wii™ activities, participants may have gained greater and more intuitive awareness of personal limitations in balance, and thus may have altered their performance on the FRT accordingly following the intervention.

Similarly, it is also possible that participants may have been anxious to please the study investigators at the beginning of the study, thus possibly over-reaching during the initial FRT. This behaviour was evidenced as some participants appeared to be impulsive during the initial testing session as they were observed to reach too far forward, stumble and almost fall on more than one occasion. Moreover, some participants needed to practice the FRT several times before a proper measurement could be obtained during baseline testing. It is possible that these difficulties could be attributed to motor planning difficulties that are commonly associated with brain injury (Manes et al., 2002). The difficulties encountered with the FRT suggest that in future studies with this population, an outcome measure that is more easily understood by persons with ABI may need to be used, or a standardized period of training in completing the FRT may need to be incorporated before baseline measures are collected.

Finally, although lower FRT scores are typically considered to be an indicator of poorer balance, it is possible that lower scores within this population and context, could in fact be interpreted as an improvement. For example, the Wii™ intervention was designed to teach participants to have a better understanding of their limits of stability through repetitive weight shifting activities. It is possible that during the course of practicing the balance activities that participants were made more aware of their balance limitations thus performed more cautiously/safely following the intervention. Support for this later explanation was observed during the collection of the post intervention balance measures as no one stumbled and fewer attempts were needed to obtain post-measures.

Although the current study findings are in agreement with previous research wherein no statistically significant improvements were identified, the fact remains that statistically significant differences have been previously identified following the implementation of Wii™ based interventions. For example, Williams et al. (2011) conducted a 4-week study with community living older adults and found significant improvements in balance after completing 12, 20 minute exercise sessions with Wii Fit™ balance and aerobic games. Significant improvements in balance were also reported by Bomberger (2010), whereby older adults engaged with Wii Fit™ balance games. One possibility that may explain the differential findings could be that both of these aforementioned studies were carried out with older adults residing in community living facilities; and it may be that adults living with ABI, as a group, are sufficiently different than this comparison group that the methods of implementing an exercise program using the Wii Fit™ need to be specifically adapted for individuals with ABI. This notion is supported by some of the qualitative feedback received within this study, in which participants discussed the need to have a longer duration within a study to practice with the Wii™ and greater flexibility in timing (both time of day and length of sessions) to suit individual functional needs and strengths.

While differences between study samples may account for some of the differential findings, this is likely not to be the only factor at play as differences persist even when the results of the present study are compared to previous work within similar samples. For example, Ding et al. (2013) demonstrated that the Nintendo Wii Fit™ gaming system could be an effective tool for encouraging stroke patients with hemiparesis to increase the use of their paretic leg. This study revealed that, by using the Wii™ to independently manipulate the influence of each leg, participants showed improvement in weight symmetry, dynamic stability, and the ability to maneuver their center of pressure. Similarly, Gil-Gomez et al. (2011) demonstrated that participants recovering from a diverse range of ABI's including stroke, TBI, and benign cerebral neoplasm, who engaged in Wii™ balance training demonstrated significant improvements in balance measures compared to patients who received traditional therapy.

One alternative possibility that may explain the differential findings could be related to the fact that the current study employed a sample size (N=7) that affords limited statistical power. In comparison, several of the studies that reported significant findings involved samples that were twice as large. For example, Bomberger (2010) reported statistically significant differences within 14 elderly individuals, Williams et al. (2011) enrolled 22 elderly individuals and reported significant results and de Kloet et al. (2012) and Gil-Gomez et al. (2011) established significance within their studies that contained 45 and 17 individuals with ABI respectively. Along similar lines, most previous research in this area has examined the utility of the Wii™ to bring about rehabilitation improvements among individuals in the acute stage of recovery wherein there is substantial room for improvement. In comparison, the sample used in the current study consisted of individuals who were on average 30 years post injury, and who had previously completed rehabilitation treatment, thus were therefore likely to have a diminished capacity to experience functional gains thus resulting in a diminished effect size.

It is also likely that differences in intervention potency across studies are a key-contributing factor for the differential findings observed. In the current study, participants were asked to engage in two 30 minute Wii™ based exercise sessions per week for 4-weeks, for a total of 240 minutes of training. In comparison, studies consisting of Wii™ and VR based activity conducted by Bomberger et al. (2010), Thornton et al. (2005), and, of particular relevance to the current study, Gil-Gomez et al. (2011), entailed participants completing two 30 minute sessions for 6-weeks, three 50 minute sessions for 6-weeks, and three to five 60 minute sessions for 4-weeks, equating to total intervention times of 360 minutes, 900 minutes, and 720 to 1200 minutes of intervention respectively. It is possible that the shorter exercise sessions, and brief length of intervention employed within the current study lead to the current study failing to meet statistical significance. Furthermore, participants in the current study were limited to engage in activities that utilized the Wii Balance Board™ and were restricted to certain games within the balance domain of the Wii Fit Plus™. In comparison, Williams et al. (2011) asked participants to engage in both Wii Fit Plus™ balance games and aerobic games. It is possible that the difference in game selections could have contributed to different findings as the games target different aspects of balance. For example the activities associated with Wii Fit Plus™ (table tilt, ski slalom, balance bubble, soccer heading, tight rope walking, and penguin slide) require the user to make gently controlled movements which are centered around shifting their weight forwards and backwards and side to side to develop static balance. In contrast Wii Fit™ games from the aerobic domain, offer a variety of activities such as step training and rhythmic boxing that are more focused on rapid and powerful movements that target developing dynamic balance. Similarly, participants in the current study were not permitted to engage in certain games (i.e., snowboard slalom, yoga, and ski jump) as it was thought these games may place individuals at too great a risk for a fall. Of particular interest is the snowboard slalom activity as this activity was included in a study by Bomberger (2010) wherein significant results were reported. It is possible that significant improvements reported by Bomberger (2010) and not in the current investigation were in part due to the fact that Bomberger (2010) included the snowboard slalom game that requires the user to adopt a narrow stance while shifting their weight forwards and backwards, whereas the current study did not.

Community integration.

Consistent with the findings reported for balance and balance confidence, measures of community integration were found to improve from pre- to post-intervention; however the change was not statistically significant. Although previous research has identified the CIQ to be an adequate measure of change among individuals with ABI (e.g., Cicerone, Mott, Azulay, & Friel, 2004; Goranson, Graves, Allison, & La Freniere, 2003; van Baalen, Odding, van Woensel, & Roebroeck, 2006), the current findings do not support these findings. One possible explanation that may account for why the CIQ measure was not found to improve to the point of reaching statistical significance may be related to the sensitivity of the measure. Although previous studies have identified that the CIQ has excellent test-retest reliability (Willer et al., 1994; Zhang et al., 2002), and to be highly sensitive immediately following injury (up to twenty-four months post injury), the longer time passes since injury the less sensitive the measure becomes (Gurka et al., 1999; Seale et al., 2002). Given that the mean time since injury in the current study was 30 years, it is possible that the CIQ was not sensitive enough to detect the extent of change that may have resulted following the Wii™ intervention.

Furthermore, the CIQ has also been reported to be susceptible to a ceiling effect, particularly within the *Social* subscale (Sander et al., 1999). Support for this possibility is evidenced in the current study as both pre and post social sub score measures were on the high end of the scale, with two participants (P07, P08) attaining the highest possible score at the post intervention time period. It is possible that participants in the current study easily reached the ceiling point for this measure as many participants rated themselves as already being highly social at the outset of this study. This comes as no surprise, however, as all participants were recruited from within, a local day program that encourages interaction, teamwork and friendships with other individuals living with ABI.

It is also possible that the CIQ did not identify significant changes in relation to community integration, as the items on the measure were devised such that they failed to take into consideration the context in which the individuals in the current study live. For example, items 13 and 14 ask respondents to provide information about their productivity, however the response options provided focus only on formal work and educational training, both of which individuals living with an ABI are unlikely to engage in (Seale et al., 2001). If the questions were tailored to better capture activities that are typically performed within an ABI population (i.e., provide response options related to volunteering and informal training as a productive activity) it is likely that results would have identified greater changes in this domain following the intervention. For example, participants in the current study who were quite involved with volunteer work scored 3 points less-than half the maximum score in the sub-measure of productivity; exemplifying how the CIQ is not as sensitive to recognizing volunteer activities that individuals find meaningful, productive and furthermore important to their community. Further evidence to support the notion that the CIQ may not have captured the essence of community integration within the current sample can be seen as the test scores in the current study failed to follow expected trends. For example, although it has been noted that females typically score higher in the sub-measure of home and individuals of older age score lower in the sub- measure of productivity (Sander et al., 1999), these trends were not apparent in this study.

Occupational improvements.

Although the observed trend towards improvement in occupational performance on the total COPM score did not reach a level of statistical significance under multivariate analysis, univariate analyses revealed a statistically significant effect in the performance domain of this scale. This finding offers important implications as it indicates that the participants' ability to perform occupational tasks and activities improved from pre- to post-intervention. Given that the COPM asks individuals to identify personally important problems in the areas of self-care, productivity, and leisure, the identified improvement in performance suggests that the Wii™ intervention aided participants in achieving their individual occupational goals. The Wii™, therefore, may have served to lessen the participants' perceived level of impairment and disability by engaging them in a novel, challenging, and motivating activity. This is supported by qualitative feedback that suggests that, prior to the intervention, participants may not have viewed themselves as capable of achieving success in an activity like the Nintendo Wii™. For example, following the Wii™ intervention P04 stated, "I'm successful at trying new things. Feel I can try new things, feel good about it." Similarly, P07 stated, "Did something I have never thought I would do," and P05 stated, "Something never done before," and "My self-esteem is up! Feel proud you actually could do it." These participant reports demonstrate how the Wii™ might lead to overall levels of improvement in performance. Specifically, through the successful engagement in a novel and challenging activity, participants may feel more capable of engaging in other activities of daily life with increased levels of confidence.

The observed improvement trends in balance and balance confidence scores may also have contributed to the significant improvement identified in the performance domain of occupational performance. Research indicates that balance impairments often restrict an individual's level of occupational performance by impeding their ability to successfully perform BADLs, IADLs, and leisure activities (e.g., Bier et al., 2009; Celinder & Peoples, 2012; Eriksson et al., 2006; Wise et al., 2010). Furthermore, due to its association with a fear of falling, impaired balance can also cause individuals to avoid ADLs that involve motor movement and balance, all of which are critical for occupational performance (Collicutt McGrath, 2008). The literature also suggests that improvement in balance directly influences self-ratings on measures of occupational performance and satisfaction. The research by Kim and Park (2013) suggests that a direct causal relationship exists between balance, balance efficacy, and ADL in stroke patients. Specifically, this study found that balance self-efficacy has a direct effect on the variability in balance scores, and that balance itself has a direct effect on the variability in ADLs. This study concluded that programs designed to target self-efficacy could improve functional ability and occupational performance. Given that the present study found improvement trends in both balance and balance confidence, it can be suggested that these changes in balance contributed to the improvements identified with regards to occupational performance.

Limitations and Future Directions

Although the findings of the present study are promising, they need to be considered in light of certain limitations. One limitation of the present study was the relatively small sample size. Only seven participants in total were considered in analyses and, in effect, parametric tests of statistical significance are limited in statistical power. Despite extensive efforts to include a substantial number of participants in the study, many factors in the process of participant recruitment and data collection led to the exclusion of participants. For example, of the original 10 participants recruited for participation in the study, the initial screening process deemed only eight of those individuals eligible for inclusion. In addition, the strict timing with which interventions were conducted at the testing site limited participation. For example, one participant (P06) withdrew their enrollment in the study after baseline data was collected due to the fact that they were unavailable on the days the exercise program was scheduled to run. This small sample size may limit the generalizability of the study results, and contributed to the possibility of random error.

Also potentially affecting generalizability is the fact that the interventions occurred at a single testing site. Typically, multicentre designs are more generalizable. Future studies should recruit larger samples of participants, and apply a multicentre approach to address concerns relating to generalizability.

Another limitation of the present study was the restricted nature of the intervention sessions. Due to the pre-existing programming and activity schedule at the testing site, participant availability and access to testing rooms were limited. Specifically, interventions could only occur two times per week, for 30 minutes each, in the late afternoon/ early evening (nearing the site's scheduled suppertime). Ideally, intervention sessions would occur three times per week for 45 minutes, which is similar to the study protocol outlined in Thornton et al. (2005). As a result of this decreased level of exposure to the intervention, the present study may have experienced a decreased level of intervention potency, thus providing a possible explanation for non-significant statistical results.

Furthermore, the time constraints of the present study prevented the study participants from choosing what time of the day would be optimal for them to participate in an exercise-based intervention. Given that the interventions were conducted in the late afternoon/ early evening, some of the participants reported experiencing fatigue, which subsequently affected their performance. Participants expressed preference over exercise in the morning or mid-day as compared to in the afternoon/ early evening, as this is when they are typically more energetic and alert. Future research should use a home-based intervention strategy so as to prevent rigid scheduling, and thus address participant concerns regarding intervention time and fatigue. Home-based interventions provide participants with a greater level of control in the study experience, thus allowing them to match their intervention times with those times during the day that they feel to be at their peak performance.

Another limitation of the study involved the fact that only one participant engaged in the intervention session at a time, whereas the original study protocol called for group interventions so as to facilitate improvement in community integration and socialization. In this original study protocol, two participants were to simultaneously engage in the balance games; however, this was associated with safety concerns. Having the study participants play the balance games together created the possibility that they would become too competitive with one another, and thus over-exert themselves and put themselves at risk of injury. Future studies should consider having both individual and group-based components to interventions, so that participants can work on their balance impairments in a safe and confidential setting, while also having the opportunity to socialize with other individuals. It remains a possibility that group training sessions may enhance social skills and foster community integration; however, it is recommended that clinicians and researchers pay particular attention to individual characteristics and group dynamics so as to avoid any adverse events occurring from over-competitiveness.

Despite these limitations, the primary purpose of the study was to explore the feasibility of using the Nintendo Wii™ in a sample of individuals with balance impairment following brain injury. To this end, the goal of the study was achieved, and numerous important findings were revealed.

Further Considerations

For future studies examining the effectiveness of Nintendo Wii™ interventions in improving balance impairments, there are a number of alternative measurement tools that may be of beneficial use. The CB&M could not be properly administered in the present study as a result of space restrictions in the testing environment, as well as concerns with participant safety. The CB&M requires a wide amount of space for completion of tasks and, although not specified in its instructions, should be conducted in a clinical setting with proper safety equipment and supervision.

Biomechanical equipment, such as a force plate, may also be of benefit in studies examining effectiveness of Wii™ interventions. Such technology is, however, costly and not portable to community or home environments (Clark et al., 2010). Thus, biomechanical forms of data collection must be restricted to laboratory and clinical settings.

It is also recommended that research provide participants with practice phases when being tested on certain measures. In the present study, participants were found to be impulsive during administration of the FRT, thus potentially skewing results. By allowing participants to increase their level of familiarity with measures such as the FRT prior to the testing phase, improved accuracy of results may be achieved.

Chapter 5: Conclusion

Acquired Brain Injury (ABI) is an all-inclusive term including all types of brain injuries: both traumatic and other injuries to the brain after birth that are not related to a congenital or degenerative disease (Greenwald et al., 2003; Teasell et al., 2007). ABIs can result in behavioral/ emotional, cognitive, and physical impairments that in turn affect an individual's everyday life (NIH, 1999). For example, impairments to behavior and emotions may negatively impact mood and self-esteem; that could result in difficulties with engagement and participation in social settings (Durstine et al., 2000). Similarly, physical impairments such as balance and motor coordination deficits may negatively impact functional activities such as dressing or climbing stairs (Basford et al., 2003; Wade et al., 1997). ABI is the leading cause of death and disability in Canada, affecting over half a million Ontarians (Colantonio et al., 2011).

Individuals living with acquired brain injury experience functional limitations due to impairments across all of the aforementioned domains (i.e., physical, behavioral, emotional, and cognitive) but, impairments within the physical domain, specifically impairment to balance, have been reported to be particularly troublesome (Gurr & Moffat, 2001; Mrazik et al., 2000). When balance is impaired, individuals experience negative impacts on BADLs, IADLs and productive and leisure activities (Hillier et al., 1997; Hyndman & Ashburn, 2003) thus impacting how connected an individual is in their community.

Several types of traditional therapy have been used to address balance impairments amongst individuals with ABI. Traditional forms of balance rehabilitation have been based on methods from physical therapy, such as body weight-support treadmill training (Scherer, 2007; Wilson & Swaboda, 2002), vestibular rehabilitation (Gurr & Moffat, 2001; Thornton et al., 2005), and conventional physical therapy, all of which have been suggested to entail rote monotonous tasks. In contrast, incorporating the Nintendo Wii™ into the rehabilitation process, has been cited to be a fun adjunctive tool for traditional rehabilitation, specifically balance training (Bateni, 2012; Bainbridge et al., 2011; Brown et al., 2009; Celinder & Peoples, 2012; Ding et al., 2013; Gil-Gomez et al., 2011; Pigford & Andrews, 2010; Saposnik et al., 2011; Shih et al., 2010; Vernadakis et al., 2012; Williams et al., 2011; Wuang et al, 2011). The use of the

Wii™ system as a tool to train balance has many potential benefits over that of traditional therapy. In general, traditional therapy is relatively expensive, and can result in diminished levels of adherence. Alternatively, the Wii™ system is a low cost commercially available option that has been reported to lead to excellent levels of adherence (Holmes et al., 2013; Williams et al., 2011).

Although the Wii™ has been examined for its efficacy among several diverse rehabilitation contexts and has contributed to an understanding of the effects of implementing the Wii™ as a clinical rehabilitation tool; currently the literature contains a paucity of research examining the use of the Nintendo Wii™ in a community population of individuals with ABI.

The results of this study extend the findings of (and Gil-Gomez et al., 2011; and Thornton et al., 2005; Williams et al., 2011) to support the viability of the Nintendo Wii™ as a method to improving balance with individuals with ABI, several years after having completed formal rehabilitation. Furthermore, results support the feasibility of using the Wii™ exercise program in a community setting without the presence of rehabilitation professionals. Statistically significant improvements were noted in occupational performance (COPM) indicating that the Wii™ exercise program has the potential to positively affect an individual's occupational performance. Although the Wii™ training program did not elicit statistically significant improvements in balance (FRT, ABC, mCB&M) and community integration (CIQ), clear trends for balance and community integration to improve were evident. Moreover, qualitative data gathered from participants was generally positive and identified that the training program was fun and motivational.

In conclusion, conventional therapy interventions are costly and can be repetitive, tedious, and lacking in the ability to attain and or preserve the interest of patients. The Nintendo Wii™ offers engaging exercises that are fun and motivational capturing an individual's attention. Ultimately enhancing an individual's balance through the use of the Nintendo Wii™ may further individuals to become more active in everyday activities and routines thus improving occupational performance and in turn community integration. Given the improvements in occupational performance and the trends toward improvements in subscales of the mCB&M and the ABC, it would be worthwhile to consider a full study of the Wii Fit™ with community-dwelling adults with ABI who are post-rehabilitation. However, such a study should be designed to incorporate recommendations arising from the qualitative data in the present feasibility study.

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Appendix A

HEALTH SCIENCES RESEARCH ETHICS BOARD
APPROVAL FORM

Western

Research Ethics

Use of Human Participants - Ethics Approval Notice

Principal Investigator: Dr. Jeffrey Holmes
File Number:103110
Review Level: Delegated
Approved Local Adult Participants:10
Approved Local Minor Participants:0
Protocol Title: The effects of virtual reality rehabilitation on balance following acquired brain injury: A pilot study
Department & Institution: Health Sciences\Occupational Therapy,Western University
Sponsor:
Ethics Approval Date: November 19, 2012 **Expiry Date:**November 30, 2014
Documents Reviewed & Approved & Documents Received for Information:

Document Name	Comments	Version Date
Other	Community Balance & Mobility Scale (CB&M)	
Other	The Activities Specific Balance Confidence Scale	
Other	Demographic Survey	
Letter of Information & Consent	LOI & Consent	
Western University Protocol		
Other	CIQ_Revised	2012/11/05
Other	COPM_Revised	2012/11/05
Other	DBIS_Revised	2012/11/05

This is to notify you that The University of Western Ontario Research Ethics Board for Health Sciences Research Involving Human Subjects (HSREB) which is organized and operates according to the Tri-Council Policy Statement: Ethical Conduct of Research Involving Humans and the Health Canada/ICH Good Clinical Practice Practices: Consolidated Guidelines; and the applicable laws and regulations of Ontario has reviewed and granted approval to the above referenced revision(s) or amendment(s) on the approval date noted above. The membership of this REB also complies with the membership requirements for REB's as defined in Division 5 of the Food and Drug Regulations.

The ethics approval for this study shall remain valid until the expiry date noted above assuming timely and acceptable responses to the HSREB's periodic requests for surveillance and monitoring information. If you require an updated approval notice prior to that time you must request it using the University of Western Ontario Updated Approval Request Form.

Members of the HSREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the HSREB.

The Chair of the HSREB is Dr. Joseph Gilbert. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

Appendix B

LETTER OF INFORMATION

The Effects of Virtual Reality Rehabilitation on Balance Following Acquired Brain Injury

INVESTIGATORS:

Lisa Klinger, MScOT
Jeffrey Holmes, PhD
Dave Walton, PhD
Mary Jenkins, BSc (PT), MD, FRCPC
Taylor Randall (MSc. Student)

You are invited to participate in a study in which we will evaluate the effects of a 4 week rehabilitation program designed around the popular virtual reality gaming system (Nintendo Wii) on increasing balance among individuals with acquired brain injury.

Background

Increasingly, the Nintendo Wii virtual reality gaming system has been cited as a potential adjunctive tool for rehabilitation. Although several press releases have highlighted the benefits of using the Wii system in clinical settings, evidence supporting the use of the Wii for rehabilitation following acquired brain injury remains limited.

Inclusion and Exclusion Criteria

We plan to test a total of 10 participants. In order to be eligible for participation, you must be at least 18 years of age, a minimum of two years post-brain injury, have been with local day program assisting individuals with ABI at least one year, experience balance impairments and or have a fear of falling that limit your occupational performance.

You will not be eligible to participate if you have recently incurred your brain injury (<2 years), have not been with the day program for at least a year, are deemed by the day program to be at risk of injuring yourself or others if you participate in the study, or if you do not identify any balance impairments or fears of falling that limit your daily occupations.

Description of Research

You will be provided with access to a Nintendo Wii video gaming system (console, controller, television, and software) for the duration of your involvement in this study. The video game system will be available for you to use during supervised sessions that will take place at a local day program. During each session you will be asked to engage in a variety of games that target physical (i.e., balance) rehabilitation. Games will be completed individually. In total, you will be asked to participate in two, 30-minute sessions per week, for 4 consecutive weeks.

To help you become familiar with the Wii gamming system, you will be given an orientation to the Wii console and controller, and will receive instruction (and see demonstrations of) the safe performance of the activities included in the rehabilitation program, including methods for grading the activity difficulty (e.g., performing balance activities with a chair in front to hold for added support).

In addition to participating in the rehabilitation program you will be assessed on site at a local day program at two different time points throughout the study: (1) Baseline (within 1 week prior to starting the rehabilitation program; (2) post-intervention (within 1 week after completing the rehabilitation program.) The testing protocol will be identical at both time periods. The tasks involved in each testing session will take approximately 90 minutes to complete, and should involve no risks or discomforts beyond those normally experienced by you in performing tasks that are commonly encountered in community environments such as walking up stairs, or crouching down to pick an object up off of the floor.

During each pre-and-post assessment time period you will be asked to complete the Community Balance and Mobility Scale, a measure that requires you to complete 13 balance related tasks. You will also be asked to complete the Functional Reach Task, an assessment that measures how far forward you can reach without loosing your balance. In addition to these physical measurements, you will also be asked to complete questionnaires that ask you about your occupational performance, balance confidence, and community participation. Finally, you will be asked to participate in a semi-structured interview where you will be asked to provide information about your rehabilitation goals and about the rehabilitation program.

Potential Benefits

Although you may not experience any direct benefits from participating in this research, we anticipate that you will experience an improvement in your balance, which may help to increase your ability ot participate within the community.. In addition, we anticipate that the results obtained through this study will provide us with valuable information concerning the benefits of implementing the Wii gaming system as a clinical rehabilitation tool. This information may also lead to the development of a series of protocols that would be useful as adjunctive therapy for the rehabilitation of acquired brain injury.

Potential Risks or Discomforts

There is a small risk in this study that you may experience a temporary loss of balance while performing the balance activities that comprise the training program, and/or during the completion of tasks used to assess your balance.

Voluntary Participation and Protection of Information

Your participation in this research project is voluntary. You may refuse to participate, refuse to answer any questions, and you may withdraw your participation at any time with no effect on your future participation in activities sponsored by the University or community program/Dale

Brain Injury Services. If you withdraw your participation in the study before the conclusion of data collection, your data will be destroyed. In order to assure complete confidentiality, no identifying information will be attached to the data collected in this study. The only record of your name that will be retained will be on the attached consent form, and this information will be stored in a locked file cabinet, within a locked room, that is (in turn) inside the Interdisciplinary Movement Disorders Laboratory (which remains locked at all times). This information will not be linked, in any way, with the study information. This also means that your data may not be withdrawn from the study after the testing session is concluded, and the information is entered into the computer. If the results of this study are published, your name will not be used, and no information that discloses your identity will be released or published without your explicit consent to the disclosure. Electronic data collected during the course of this study will be kept indefinitely.

You will not receive remuneration for participation in this study.

Further Questions

If you have any questions about this research project, please contact the principal investigators, Dr. Jeffrey Holmes, at or by email at , or Professor Lisa Klinger at , or by email at . If you have any questions about your rights as a research participant, or the conduct of this study, you may contact the Office of Research Ethics at, , or email: . You are not waiving any legal rights by signing the attached consent form. This letter is yours to keep.

Appendix C

CONSENT TO PARTICIPATE IN RESEARCH FORM

The Effects of Virtual Reality Rehabilitation on Balance

Following Acquired Brain Injury

Please sign this form to indicate that you agree with the following statement:

I have read the Letter of Information, have had the nature of the study explained to me, and I agree to participate. All questions have been answered to my satisfaction.

Participant (Printed Name):

____

Participant (Signature):

____

Person Obtaining Informed Consent (Printed Name):

____

Person Obtaining Informed Consent (Signature):

____

Date: _____________________________

Appendix D

FUNCTIONAL REACH TEST (FRT)

Functional Reach Test

The Functional Reach Test is a single item test developed as a quick screen for balance problems in older adults.

Interpretation:
A score of 6 or less indicates a significant increased risk for falls.
A score between 6-10 inches indicates a moderate risk for falls.

Age related norms for the functional reach test:

Age	Men (in inches)	Women (in inches)
20-40yrs	16.7 ± 1.9	14.6 ± 2.2
41-69yrs	14.9 ± 2.2	13.8 ± 2.2
70-87	13.2 ± 1.6	10.5 ± 3.5

Requirements:
The patient must be able to stand independently for at least 30 seconds without support, and be able to flex the shoulder to at least 90 degrees.

Equipment and Set up:
A yard stick is attached to a wall at about shoulder height. The patient is positioned in front of this so that upon flexing the shoulder to 90 degrees, an initial reading on the yard stick can be taken. The examiner takes a position 5-10 feet away from the patient, viewing the patient from the side.

Instructions:
Position the patient close to the wall so that they may reach forward along the length of the yardstick. The patient is instructed stand with feet shoulder distance apart then make a fist and raise the arm up so that it's parallel to the floor. At this time the examiner takes an initial reading on the yard stick, usually spotting the knuckle of the third metacarpal. The patient is instructed to reach forward along the yardstick without moving the feet. Any reaching strategy is allowed but the hand should remain in a fist. The therapist takes a reading on the yardstick of the farthest reach attained by the patient without taking a step. The initial reading is subtracted from the final to obtain the functional reach score.

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Appendix E

COMMUNITY BALANCE AND MOBILITY MEASURE (CB&M)

COMMUNITY BALANCE & MOBILITY SCALE

1. UNILATERAL STANCE
i) Test to be performed on right leg
ii) Test to be performed on left leg
Starting position: Standardized starting position.
Instructions to Patient: *Stand on your right/left leg and hold for as long as you can up to 45 seconds.Look straight ahead.*
Instructions to Therapist: Begin timing as soon as the patient's foot leaves the ground. Do not allow the patient to brace the elevated leg against the supporting leg.
Test is over: Stop timing if stance foot moves from starting position or opposite foot touches ground.

GRADING:
0 unable to sustain unilateral stance independently, i.e. able to unweight leg for brief moments only
1 able to sustain unilateral stance for 2.00 - 4.49 sec.
2 able to sustain unilateral stance for 4.50 - 9.99 sec.
3 able to sustain unilateral stance for 10.00 - 19.99 sec.
4 able to sustain unilateral stance for > 20.00 sec.
5 able to sustain unilateral stance for 45.00 sec. in a steady & coordinated manner
NOT Acceptable: excessive use of equilibrium reactions

2. TANDEM WALKING
Starting position: Standardized starting position with one foot positioned on the 8m line.
Instructions to Patient: *Walk forward on the line, heel touching toes. Keep your feet pointing straight ahead. Look ahead down the track, not at your feet. I will tell you when to stop.*
Instructions to Therapist: If able, allow the patient to take a maximum of 7 steps. For your scoring, count only those consecutive steps for which the heel is on the line and the heel-toe distance is < 8cm (3 inches).

GRADING:
0 unable to complete 1 step on the line independently, i.e. requires assistance, upper extremity support, or takes a protective step
1 able to complete 1 step independently, acceptable to toe out
2 able to complete 2 or 3 steps consecutively on the line, acceptable to toe out
3 able to complete more than 3 steps consecutively, acceptable to toe out
4 able to complete more than 3 steps consecutively, in good alignment (heel-toe contact, feet straight on the line, no toeing out), but demonstrates excessive use of equilibrium reactions
5. able to complete 7 steps consecutively, in good alignment (heel-toe contact, feet straight on the line, no toeing out), and in a steady & coordinated manner.
NOT Acceptable: excessive use of equilibrium reactions looking at feet

3. 180 TANDEM PIVOT
Starting position: Tandem Stance on bare spot in track (see set-up diagram) – aligned heel to toe, no toeing out, arms at sides, head in neutral position and eyes forward. Patient allowed to choose either foot in front and may use assistance or upper extremity support to achieve, but not sustain, tandem stance.
Start Action Finish
Instructions to Patient: *Lifting your heels just a little, pivot all the way around to face the opposite direction without stopping. Put your heels down and maintain your balance in this position.*
Instructions to Therapist: When right foot is in front in tandem position, patient to turn towards left. When left foot is in front in tandem position, patient to turn towards right. Therapist may assist patient to assume starting position.
Test is over: When patient puts heels down or steps out of position.

GRADING:
0 unable to sustain tandem stance independently, i.e. requires assistance or upper extremity support
1 able to sustain tandem stance independently, but unable to unweight heels and/or initiate pivot
2 able to initiate pivot, but unable to complete 180. requi3 able to complete 180° turn but discontinuous, i.e. pauses on toes during pivot
4 able to complete 180° turn but discontinus motion, but unable to sustain reversed position
NOT Acceptable: heel-toe distance > 8cm (3 inches)
5 able to turn 180> 8cm (3 inches)s and coordinated motion and sustain reversed position (Acceptable to have feet slightly angled out in reversed position)
NOT Acceptable: heel-toe distance > 8cm (3 inches); excessive use of equilibrium reactions

4. LATERAL FOOT SCOOTING
Lateral foot scooting is defined as alternately pivoting on the heel and toe of one foot while moving sideways.
i) move to the right when performing on right leg
ii) move to the left when performing on left leg
Starting position: Standing on the line beside the bare spot in unilateral stance on right/left foot, arms at sides. Foot is perpendicular to the track.
Instructions to Patient: *Stand on your right/left leg and move sideways by alternately pivoting on your heel and toe. Keep pivoting straight across until you touch the line and maintain your balance in this position.*
Instructions to Therapist: The patient moves laterally along the length of the bare spot (40cm). For the grading, one lateral pivot is defined as either pivoting on heel, moving toes laterally OR pivoting on toes, moving heel laterally.
Test is over: When patient steps, hops, or touches opposite foot to □oor.

GRADING

0 unable to sustain unilateral stance independently, i.e. requires assistance or upper extremity support
1 able to perform 1 lateral pivot in any fashion
2 able to perform 2 lateral pivots in any fashion
3 able to perform > 3 lateral foot pivots, but unable to complete 40cm
4 able to complete 40cm in any fashion, acceptable to be unable to control final position
5 able to complete 40cm in a continuous and rhythmical motion, demonstrating a controlled stop briefly maintaining unilateral stance
NOT Acceptable: pausing while pivoting to regain balance from a straight line course excessive use of equilibrium reactions excessive trunk rotation while pivoting

5. HOPPING FORWARD
i) to be performed on right leg
ii) to be performed on left leg
Starting position: Unilateral stance on right/left with entire foot on the track. Heel placed on inside edge of starting line.
Instructions to Patient: *Stand on your right/left foot. Hop twice straight along this line to pass the 1m mark with your heel. Maintain your balance on your right/left leg at the finish.*
Instructions to Therapist: It is recommended that the therapist assess safety prior to commencing task by having the patient hop in one spot. Patient is successful in completing 1m when the heel of the foot is touching or beyond the 1m line.
Test is over: If patient touches down with suspended foot between hops.

GRADING
0 unable to sustain unilateral stance independently or hop, i.e. requires assistance or upper extremity support
1 able to perform 1 or 2 hops with poor control, i.e. unable to sustain 1 foot landing for even brief moments, unable to complete 1m
2 able to perform 2 hops sequentially in a controlled manner, unable to complete 1m
3 able to complete 1m in 2 hops, but unable to sustain 1 foot landing, i.e. touches down or steps with opposite limb upon landing. Acceptable to deviate from the line
4 able to complete 1m in 2 hops, but difficulty controlling landing, i.e. hops or pivots on stance foot to maintain landing. Acceptable to deviate from the line
NOT Acceptable: touching down or stepping with opposite limb to achieve stability on landing
5 able to complete 1m in 2 hops in a coordinated manner and sustain a stable landing
NOT Acceptable: deviate from line excessive use of equilibrium reactions

6. CROUCH AND WALK
Starting Position: Standardized starting position. Bean bag is placed to right or left side of the 2m mark considering which hand the patient will use to pick it up.
Instructions to Patient: *Walk forward and, without stopping, bend to pick up the bean bag and then continue walking down the line.*
Instructions to Therapist: This task is performed using only half of the track. Start timing when the patient's foot leaves the ground. Stop timing when both feet cross the 4m line.

Patient should use the less affected upper extremity for the task. This will avoid downgrading the score due to limitations of upper extremity function as opposed to balance function.

GRADING
0 unable to crouch (descend) to pick up bean bag independently, i.e. requires assistance or upper extremity support
1 able to crouch (descend), but unable to maintain crouch to pick up bean bag or rise to stand independently, i.e. requires assistance or touches hands down to floor
2 able to crouch to pick up bean bag and rise to stand independently but must hesitate at any time during activity, i.e. unable to maintain forward momentum
3 able to crouch and walk in a continuous motion (i.e. maintaining forward momentum) with time < 8.00 seconds and demonstrates protective step at any time during the task
4 able to crouch and walk in a continuous motion with time < 8.00 seconds and/or uses excessive equilibrium reactions to maintain balance at any time during the task
NOT Acceptable: veering off course
5 able to crouch and walk in a continuous and rhythmical motion with time < 4.00 seconds
NOT Acceptable: veering off course excessive use of equilibrium reactions

7. LATERAL DODGING
Starting Position: Standing at the 2m mark with feet perpendicular to the track. The toes of both feet should cover the track
Instructions to Patient: *Move sideways along the line by repeatedly crossing one foot in front of and over the other. Place part of your foot on the line with every step. Reverse direction whenever I call "Change!r I ca Reverse directionour foot on the line witintain forward mo***Instructions to Therapist:** Patient moves laterally back and forth along the line, between the 2m and 4m marks by repetitively crossing one foot over and in front of the other.
It is acceptable for the patient to look at the line to monitor foot placement.
One cross-over includes crossing one leg over to land beside the other and returning the back leg to an uncrossed position.
One cycle requires the patient to cross-over for a 2m distance and return. The test requires that the patient perform two of these cycles (a total of 8m). Begin timing as soon as the patient's foot leaves the ground. Stop timing when both feet cross over the □nal mark. To cue the patient to change direction, call out "Change!" when one foot passes the 2 and 4m marks. The patient should believe direction changes are random.

GRADING
0 unable to perform one cross-over in both directions without loss of balance or use of support.
1. able to perform one cross-over in both directions without use of support, but unable to contact the line with part of the foot.
2 able to cross-over for 1 or more cycles to and from the 2m mark, but unable to contact the line with every step.
3 able to perform 2 cycles in any fashion (to the 2m line and back twice) and one part of each foot must contact the line during each step.
4. performs 2 cycles as described in level 3 in 12.00 to 15.00 sec.

5. performs 2 cycles in less than 12.00 sec. in a continuous, rhythmical fashion with coordinated direction changes immediately after verbal cue.

8. WALKING & LOOKING
i) to be performed looking right
ii) to be performed looking left
Starting position: Standardized starting position. (See set-up diagram for placement of visual target.)
Instructions to Patient: *Walk at your usual pace to the end of the line. I will tell you when to look at the circle. Keep looking at it while you walk past it. I will then tell you when to look straight ahead again. Try not to veer off course while you walk.*
Instructions to Therapist: Score client as defined in the guidelines, irrespective of the underlying limiting impairments, e.g. decreased neck or trunk rotation. Start timing when the patient's foot leaves the ground. Stop timing when both feet cross the 8m finish line.
1. At the 2m mark, ask the patient to "Look at the circle."
2. Cue the patient to "Keep looking at the circle" as they look back over their shoulder until they reach the 6m mark.
3. At the 6m mark, ask the patient to "Look straight ahead and continue walking until the end of the line."
Stand in a location where the patient's ability to maintain fixation can be assessed, that is, beside the target. Thus, a second person may be needed to walk with the patient to ensure safety. It is acceptable to continue to remind the patient of where they should be looking at each segment.
To score in the opposite direction, repeat task starting from opposite end of the line.

GRADING
0 unable to walk and look, i.e. has to stop to look, or requires assistance or upper extremity support at any point during the test
1 able to continuously walk and initiate looking, but loses visual fixation on circle at or before 4m mark
2 able to continuously walk and look, but loses visual fixation on circle after 4m mark, i.e. while looking back over the shoulder
3 able to continuously walk and fixate upon the circle between the 2m and 6m mark, but demonstrates a protective step.
4 able to continuously walk and fixate upon the circle between the 2m and 6mmark, but veers off course at any time during task.
5 able to continuously walk and fixate upon circle between the 2m and 6m mark, maintains a straight path, in a steady and coordinated manner, time < 7.00 sec.
NOT Acceptable: inconsistent or reduced speed looking down at feet

9. RUNNING WITH CONTROLLED STOP
Starting position: Standardized starting position.
Instructions to Patient: *Run as fast as you can to the end of the track. Stop abruptly with both feet on the finish line and hold this position.*

Instructions to Therapist: Begin timing when initial foot leaves ground. Stop timing when both feet reach the finish line. It does not matter whether the feet land consecutively or simultaneously on the finish line.

GRADING
0 unable to run (with both feet off ground for brief instant), rather demonstrates fast walking or leaping from foot to foot
1 able to run in any fashion, time > 5.00 sec.
2 able to run in any fashion, time > 3.00 sec. but < 5.00 sec., but is unable to perform a controlled stop with both feet on the line, i.e. uses protective step or excessive equilibrium reactions
3 able to run in any fashion, time > 3.00 sec. but < 5.00 sec., and perform a controlled stop with both feet on the line
NOT Acceptable: excessive use of equilibrium reactions
4 able to run in any fashion, time < 3.00 sec., but is unable to perform a controlled stop with both feet on the line, i.e. uses protective step(s) or excessive equilibrium reactions
5 able to run in a coordinated and rhythmical manner and perform a controlled stop with both feet on the line, time < 3.00 sec.
NOT Acceptable: excessive use of equilibrium reactions

10. FORWARD TO BACKWARD WALKING
Starting position: Standardized starting position.
Instructions to Patient: *Walk forwards to the halfway mark, turn around and continue to walk backwards until I say ark, turn around and continuerform a controlledep or.)in your balanceo a speed that you feel safe.*
Instructions to Therapist: Start timing when the patient's foot leaves the ground. Stop timing when both feet cross the 8m finish line. The patient is to turn at the 4m mark. It is acceptable for the subject to turn in any direction s/he chooses.
• When counting the steps required to turn 180°:
i) the first step in the turn is angled away from the forward trajectory,
ii) the last step in the turn completes the 180° turn and is oriented towards the starting line, initiating backwards walking.
• It is also acceptable to pivot on one foot rather than stepping around.

GRADING
0 unable to complete task, i.e. requires assistance or upper extremity support
1 able to complete task independently, but must stop to maintain/regain balance
at any time during this task
2 able to complete the task without stopping but must significantly reduce speed, i.e. total time is > 11.00 sec., AND/ OR requires 4 or more steps to complete the turn
3 able to complete task with time < 11.00 sec. and/or veers from straight path during backwards walking
4 able to complete task in a continuous motion, time < 9.00 sec., and/or uses protective step(s) during or just after turn
5 able to complete the task in a continuous motion with brisk speed, time < 7.00 sec. and maintaining a straight path throughout

11. WALK, LOOK & CARRY
i) to be performed looking right
ii) to be performed looking left
Starting position: Standardized starting position, but carrying a plastic grocery bag in each hand by the handle, with a 7 1⁄2 lb. = 3.4 kg weight inside each bag. (See set-up diagram for placement of visual target.)
Instructions to Patient: *Walk at your usual pace to the end of the line carrying the grocery bags. I will tell you when to look at the circle. Keep looking at it while you walk past it. I will then tell you when to look straight ahead again. Try not to veer off course while you walk.*
Instructions to Therapist: Same instructions as in Item 8 Walking & Looking. Patient to carry only one grocery bag if unable to perform bilaterally due to motor control problems of the upper extremity.
Indicate on the score sheet if patient carried only one bag.
GRADING
0 unable to walk and look, i.e. has to stop to look, or requires assistance or upper extremity support at any point during the test
1 able to continuously walk and initiate looking, but loses visual fixation on circle at or before 4m mark
2 able to continuously walk and look, but loses visual fixation on circle after 4m mark, i.e. while looking back over the shoulder
3 able to continuously walk and fixate upon the circle between the 2m and 6m mark, but demonstrates a protective step. Acceptable for patient to demonstrate inconsistent or reduced speed
4 able to continuously walk and fixate upon the circle between the 2m and 6m mark but veers off course. Acceptable for patient to demonstrate inconsistent or reduced speed
5 able to continuously walk and fixate upon circle between the 2m and 6m mark, maintains a straight path, in a steady & coordinated manner, time < 7.00 sec.
NOT Acceptable: inconsistent or reduced speed looking down at feet

12. DESCENDING STAIRS
Starting position: Quiet standing at top of staircase (minimum 8 steps). Depending on patient's skill on the stairs, may begin by descending from the first or third step at the bottom of the right.
Instructions to Patient: *Walk down the stairs. Try not to use the railing.*
Instructions to Therapist: Depending on patient's skill on stairs, may use a cane as in level 1 and 2.
***BONUS**
If the patient achieves a score of 4 or 5, and if deemed safe by the rating therapist, the patient is asked to repeat the task and descend stairs while carrying a weighted basket (laundry basket with 2 lb. weight in it). It is acceptable for the patient to intermittently look at the steps.
Add one bonus point to the score of 4 or 5 if the patient can descend the stairs safely while carrying the basket without the need for continuous monitoring of their foot placement. If the patient is unable to hold the basket with one or both arms, they are not eligible for the bonus point.

Instructions to Patient: Hold this basket, keeping it in front of you at waist level. Walk down the stairs and try not to look at your feet. You may look at the steps once in a while for safety.

GRADING
0 unable to step down 1 step OR requires the railing or assistance
1 able to step down 1 step with/without use of cane
NOT Acceptable: use of railing (from this level onwards)
2 able to step down 3 steps in any pattern with/without the use of cane,
i.e. step-to pattern with/without cane or reciprocal pattern with cane
3 able to step down 3 steps in a reciprocal pattern, without cane OR able to step down a full right in a step-to pattern, without cane
NOT Acceptable: use of cane (from this level onwards)
4 able to step down a right in a reciprocal pattern but awkward, uncoordinated*
5 able to step down a right in a reciprocal pattern in a rhythmical and coordinated manner*

13. STEP UPS x 1 STEP
i) to be performed leading with right leg
ii) to be performed leading with left leg
Starting position: Standardized starting position in front of step at bottom of stairs.
Instructions to Patient:
i) Step up and down on this step as quickly as you can until I say .top.ep up and down on this step as and Right-Left Down. Try not to look at your feet.
ii) Step up and down on this step as quickly as you can until I say "Stop." The pattern is Left-Right Up and Left-Right Down. Try not to look at your feet.
Instructions of Therapist: Start timing when the patient's foot leaves the ground. Stop timing after the completion of 5 cycles. A cycle is one complete step up and down.

GRADING
0 unable to step up independently, requires assistance and/or railing to ascend
1 able to step up independently, but unable to step down independently, i.e. requires railing and/or assistance to descend
2. able to step up and down (1 cycle) independently without railing or assistance. Acceptable to look at feet
3. able to complete 5 cycles. Acceptable to demonstrate incoordination or inconsistent speed/rhythm
NOT Acceptable: to look at feet
4. able to complete 5 cycles in > 6.00 but < 10.00 sec. Acceptable as in Level 3
NOT Acceptable: as in level 3
5. able to complete 5 cycles in < 6.00 sec. in a rhythmical and coordinated manner
NOT Acceptable: to look at feet

Appendix F

THE ACTIVITIES SPECIFIC BALANCE CONFIDENCE SCALE (ABC)

The Activities-specific Balance Confidence (ABC) Scale*

Instructions to Participants:

For each of the following, please indicate your level of confidence in doing the activity without losing your balance or becoming unsteady from choosing one of the percentage points on the scale from 0% to 100%. If you do not currently do the activity in question, try and imagine how confident you would be if you had to do the activity. If you normally use a walking aid to do the activity or hold onto someone, rate your confidence as if you were using these supports. If you have any questions about answering the items, please ask the administrator.

The Activities-specific Balance Confidence (ABC) Scale*

For each of the following activities, please indicate your level of self-confidence by choosing a corresponding number from the following rating scale:

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

no confidence completely confident

"How confident are you that you will NOT lose your balance or become unsteady when you……….

1. … walk around your house? _____%
2. … walk up or down the stairs?_____%
3. … bend over and pick up a slipper from the front closet floor? ____%
4. … reach for a small can off a shelf at eye level? _____%
5. … stand on your tiptoes and reach for something above your head? _____%
6. … stand on a chair and reach for something? _____%
7. … sweep the floor? _____%
8. … walk outside the house to a car parked in the driveway? _____%
9. … get into or out of the car? _____%
10. … walk across a parking lot to the mall? _____%
11. … walk up or down a ramp? ______%
12. … walk in a crowded mall where people rapidly walk past you? ______%
13. … are bumped into by people as you walk through a mall? _____%
14. … step onto of off an escalator while you are holding onto a railing?______%
15. … step on or off an escalator while holding onto parcels such that that you cannot hold onto the railing? ______%
16. … walk outside on icy sidewalks? ______%

* Powell, L. E., & Meyers, A., M. The activities-specific balance confidence (ABC) scale. J Gerontol Med Sci 1995; 50(1): M28-34.

Appendix G

COMMUNITY INTEGRATION QUESTIONNAIRE (CIQ)

Community Integration Questionnaire (CIQ)

1. Who usually does the shopping for groceries or other necessities in your household?	• Yourself alone • Yourself and someone else • Someone else
2. Who usually prepares meals in your household?	• Yourself alone • Yourself and someone else • Someone else
3. In your home who usually does the everyday housework?	• Yourself alone • Yourself and someone else • Someone else
4. Who usually cares for the children in your home?	• Yourself alone • Yourself and someone else • Someone else • Not applicable not children under 17 in the home
5. Who usually plans social arrangements such as get-togethers with family and friends?	• Yourself alone • Yourself and someone else • Someone else
6. Who usually looks after your personal finances, such as banking or paying bills?	• Yourself alone • Yourself and someone else • Someone else
7. Approximately how many times a month do you usually participate in shopping outside your home?	• Never • 1-4 times • 5 or more
8. Approximately how many times a month do you usually participate in leisure activities such as movies, sports, restaurants, etc.	• Never • 1-4 times • 5 or more
9. Approximately how many times a month do you usually visit your friends or relatives?	• Never • 1-4 times • 5 or more
10. When you participate in leisure activities	• Mostly alone • Mostly with friends who have head

do you usually do this alone or with others?	injuries • Mostly with family members • Mostly with friends who do not have head injuries • With a combination of family and friends
11. Do you have a best friend with whom you confide?	• Yes • No
12. How often do you travel outside the home?	• Almost everyday • Almost every week • Seldom/ never (less than once a week)
13. Please choose the answer that best corresponds to your current (during the past month) work situation:	• Full time (more than 20 hours/week) • Part-time (less than 20 hours/week) • Not working, but actively looking for work • Not working, not looking for work • Not applicable retired due to age
14. Please choose the answer that best corresponds to your current (during the past month) school or training program situation:	• Full time • Part time • Not attending school or training program • Not applicable retired due to age
15. In the past month, how often did you engage in volunteer activities?	• Never • 1-4 times • 5 or more

Appendix H

SEMISTRUCTURED INTERVIEW GUIDELINE

Semi Structured Interview Guideline

1. Tell me about your daily activities over the past four weeks?
    a. What kinds of things have you been doing?
    b. Has there been any change in daily activities over the past four weeks and if so, can you tell me about this?
2. What do you think about the Nintendo Wii?
    a. What did you like? Dislike?
3. How does the Wii compare to other exercise programs you have done?
4. Would you want to continue to use the Wii? Why/why not?
5. Has participation in this study affected your activity or your ability to do things? If so, can you tell me about this?
6. Has participation in this study affected your balance? If so, can you tell me about this?
7. Do you think there will be lasting changes as a result of participating in this study? Can you tell me about this?

Appendix I

CANADIAN OCCUPATIONAL PERFORMANCE MEASURE (COPM)

CANADIAN OCCUPATIONAL PERFORMANCE MEASURE

Authors:
Mary Law, Sue Baptiste, Anne Carswell,
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The Canadian Occupational Performance Measure (COPM) is an individualized measure designed for use by occupational therapists to detect self-perceived change in occupational performance problems over time.

Published by CAOT Publications ACE

Client Name:		
Age:	Gender:	ID#:
Respondent (if not client):		
Date of Assessment:	Planned Date of Reassessment:	Date of Reassessment:

Therapist:
Facility/Agency:
Program:

STEP 1: IDENTIFICATION OF OCCUPATIONAL PERFORMANCE ISSUES	STEP 2: RATING IMPORTANCE
To identify occupational performance problems, concerns and issues, interview the client, asking about daily activities in self-care, productivity and leisure. Ask clients to identify daily activities which they want to do, need to do or are expected to do by encouraging them to think about a typical day. Then ask the client to identify which of these activities are difficult for them to do now to their satisfaction. Record these activity problems in Steps 1A, 1B, or 1C.	Using the scoring card provided, ask the client to rate, on a scale of 1 to 10, the importance of each activity. Place the ratings in the corresponding boxes in Steps 1A, 1B, or 1C.

STEP 1A: Self-care		IMPORTANCE
Personal Care (e.g., dressing, bathing, feeding, hygiene)		
Functional Mobility (e.g., transfers, indoor, outdoor)		
Community Management (e.g., transportation, shopping, finances)		

STEP 1B: Productivity		
Paid/Unpaid Work (e.g., finding/keeping a job, volunteering)		
Household Management (e.g., cleaning, laundry, cooking)		
Play/School (e.g., play skills, homework)		

STEP 1C: Leisure

		IMPORTANCE
Quiet Recreation (e.g., hobbies, crafts, reading)		
Active Recreation (e.g., sports, outings, travel)		
Socialization (e.g., visiting, phone calls, parties, correspondence)		

STEPS 3 & 4: SCORING - INITIAL ASSESSMENT and REASSESSMENT

Confirm with the client the 5 most important problems and record them below. Using the scoring cards, ask the client to rate each problem on performance and satisfaction, then calculate the total scores. Total scores are calculated by adding together the performance or satisfaction scores for all problems and dividing by the number of problems. At reassessment, the client scores each problem again for performance and satisfaction. Calculate the new scores and the change score.

Initial Assessment:			**Reassessment:**	
OCCUPATIONAL PERFORMANCE PROBLEMS:	PERFORMANCE 1	SATISFACTION 1	PERFORMANCE 2	SATISFACTION 2
1.				
2.				
3.				
4.				
5.				
SCORING:	PERFORMANCE SCORE 1	SATISFACTION SCORE 1	PERFORMANCE SCORE 2	SATISFACTION SCORE 2
Total score = Total performance or satisfaction scores / # of problems	/ =	/ =	/ =	/ =

CHANGE IN PERFORMANCE = Performance Score 2 [ ] − Performance Score 1 [ ] = [ ]

CHANGE IN SATISFACTION = Satisfaction Score 2 [ ] − Satisfaction Score 1 [ ] = [ ]

ADDITIONAL NOTES AND BACKGROUND INFORMATION

Initial Assessment:

Reassessment:

Curriculum Vitae

Name:	Taylor Randall
Post-Secondary Education & Degrees:	Western University London, Ontario, Canada 2006-2011 B.A
	Western University London, Ontario, Canada 2011-2013 M.S
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